

ELEKTOR ELECTRONICS

THE INTERNATIONAL
ELECTRONICS MAGAZINE

May 1994
£ 2.45

Low-voltage
CMOS devices

DIFFERENTIAL PROBE FOR OSCILLOSCOPES

Morse
decoder

Stamp BASIC
Computer

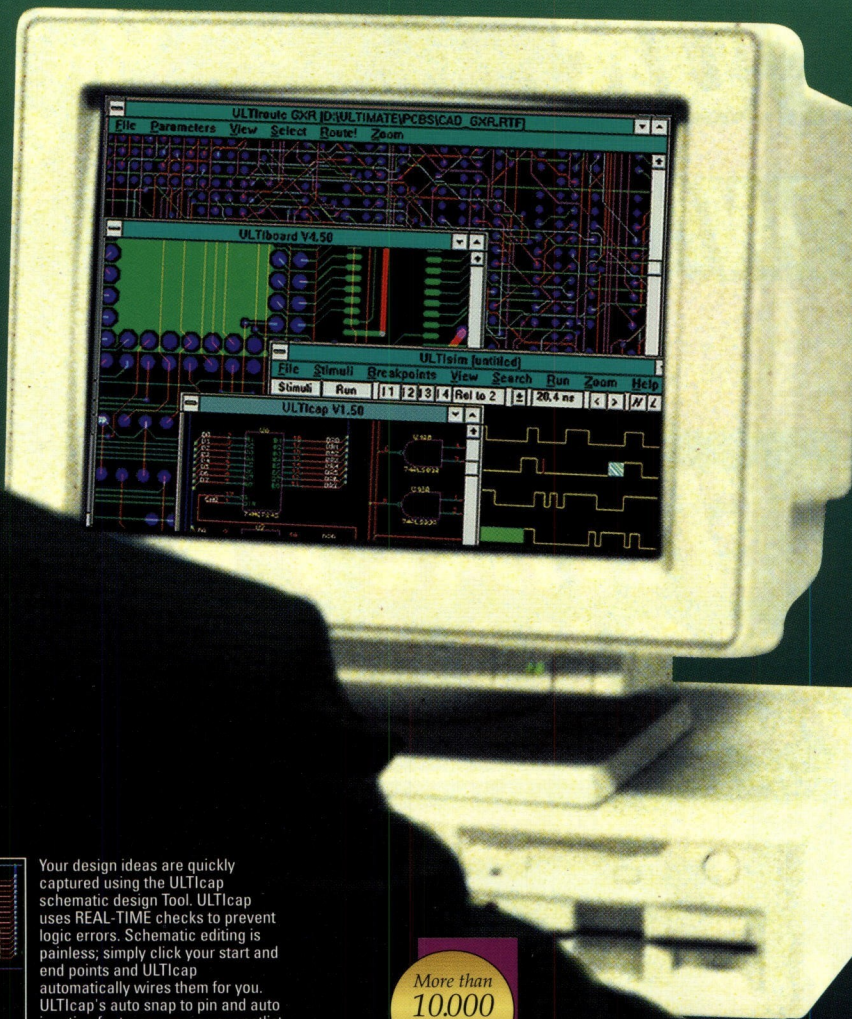
General purpose
sensor monitor

80C535 Course-Part 3



AUDIO & HI-FI • COMPUTERS & MICROPROCESSORS • DESIGN IDEAS • RADIO, TELEVISION & COMMUNICATIONS • SCIENCE & TECHNOLOGY • TEST & MEASUREMENT

FROM CONCEPT TO ARTWORK IN 1 DAY



ULTiboard, one of the leading PC based design systems, is supplied worldwide via a network of ULTimate Technology offices and distributors. ULTiboard's success in the professional design community is primarily due to its superior interactive functionality.

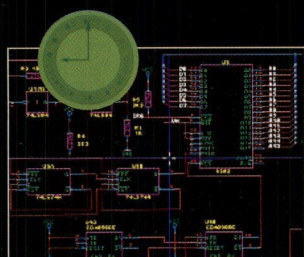
Real Time Placement Aids, Real Time Design Rule Check, Trace Reroute While Move and Trace shove, are all features which will dramatically reduce your design time.

Integration with ULTicap guarantees smooth data flow between Schematic and PCB editing and the inclusion of third party netlist interfaces ensures ULTiboard will fit into any design environment.

Another of ULTimate Technology's strengths is our flexible growth path. Users may start with a low cost ULTiboard Challenger Lite and grow, step by step, to a 32-bit Advanced system with Ripup and Retry Autorouting and Digital Simulation.

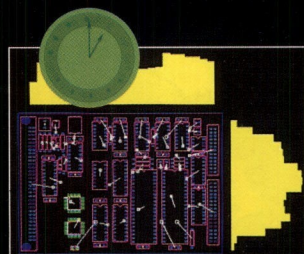
ULTimate Technology also looks after existing users, providing they have valid maintenance subscriptions they will be upgraded to a new system based on their original investment. For instance, a 1987 ULTiboard-DOSsystem has now been upgraded to a 32-bit Advanced system with Windows compliance and 2 Autorouters.

ULTimate Technology not only adds value to your investment in a ULTiboard system but backs it up with the highest quality support from our distributors and offices.

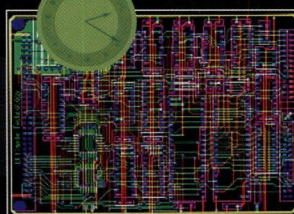


Your design ideas are quickly captured using the ULTicap schematic design Tool. ULTicap uses REAL-TIME checks to prevent logic errors. Schematic editing is painless; simply click your start and end points and ULTicap automatically wires them for you. ULTicap's auto snap to pin and auto junction features ensure your netlist is complete, thereby relieving you of tedious netlist checking.

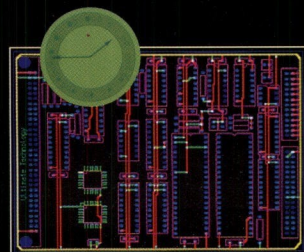
More than
10,000
Users



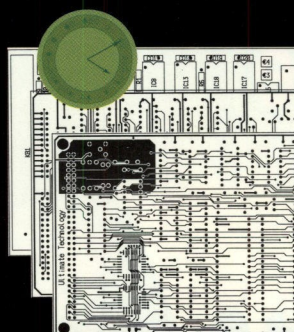
ULTishell, the integrated user interface, makes sure all your design information is transferred correctly from ULTicap to ULTiboard. Good manual placement tools are vital to the progress of your design, therefore ULTiboard gives you a powerful suite of REAL-TIME functions such as, FORCE VECTORS, RATS NEST RECONNECT and DENSITY HISTOGRAMS. Pin and gate swapping allows you to further optimise your layout.



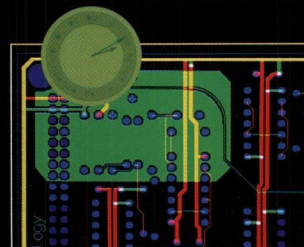
ULTiboard's autorouter allows you to control which parts of your board are autorouted, either selected nets, or a component, or a window of the board, or the whole board. ULTiboard's intelligent router uses copper sharing techniques to minimise route lengths. Automatic via minimisation reduces the number of vias to decrease production costs. The autorouter will handle up to 32 layers, as well as single sided routing.



Now you can quickly route your critical tracks. ULTiboard's REAL-TIME DESIGN RULE CHECK will not allow you to make illegal connections or violate your design rules. ULTiboard's powerful TRACE SHOVE, and REROUTE-WHILE-MOVE algorithms guarantee that any manual track editing is flawless. Blind and buried vias and surface mount designs are fully supported.



ULTiboard's backannotation automatically updates your ULTicap schematic with any pin and gate swaps or component renumbering. Finally, your design is post processed to generate pen / photo plots, dot matrix/laser or postscript prints and custom drill files.



If you need partial ground planes, then with the Dos extended board systems you can automatically create copper polygons simply by drawing the outline. The polygon is then filled with copper of the desired net, all correct pins are connected to the polygon with thermal relief connections and user defined gaps are respected around all other pads and tracks.

ULTIMATE
TECHNOLOGY

Corporate Headquarters:
Energiestraat 36 • 1411 AT Naarden
The Netherlands
tel.: (+31) 2159 - 44444
fax: (+31) 2159 - 43345

UK/Ireland Sales-Office:
2 Bacchus House • Calleva Park
Aldermaston Berkshire • RG7 4QW
tel.: 0734 - 812030 • fax: 0734 - 815323

ULTIBOARD = PRODUCTIVITY
The European quality alternative

ULTIBOARD
Challenger Lite

- ULTicap Schematics & ULTiboard PCB-Design
- DOS-Version with 500 Pin Design capacity
- 100% Compatible with 32-bit Versions
- 450 page manual PLUS full color tutorial
- Technical Support, Updates possible
- 'Growth path' to 32-bit without loss of investment

Recession-proof price:
excl. shipping/handling, VAT/ Sales tax **£ 295**

Also available is a full function (as described above, with a 350 pin design capacity) Evaluation System for only £ 75 excl shipping/handling, VAT/Sales).

In next month's issue

- 80C535 SBC extension board
- I²C bus booster
- RS485 interface
- Heat sinks – how and when to use them
- The IL300 linear optoisolator
- RC active filters
- Intelligent EPROM eraser
- Fuel consumption monitor for injection engines and more for your continued interest

Front cover

The photograph shows the differential probe described on page 22 being used to ascertain the waveform across an incandescent light bulb. The probe overcomes several shortcomings of the probe supplied with many oscilloscopes. It is a 10:1/100:1 design that enables floating measurements to be carried out. It is suitable for measuring high voltages.

© 1994 Elektuur BV.

ABC
AUDIT BUREAU OF CIRCULATIONS

CONSUMER PRESS

BOOK CREDIT VOUCHER. In this and the next issue we will publish a voucher that will entitle the holder to up to 30% discount on the purchase price of any Elektor Electronics book – page 67

COMPONENTS

- 5 Low-voltage CMOS devices
By our Editorial Staff

COMPUTERS & MICROPROCESSORS

- 33 **COURSE:** 80C535 hardware/assembler – Part 3
Software by Dr. M. Ohsmann
38 **PROJECT:** Stamp BASIC computer
Sources: Parallel Inc. USA & K.H. Eichler

GENERAL INTEREST

- 10 **PROJECT:** Mains signalling system – Part 2
Design by W. Hackländer and S. Furchtbar
28 **PROJECT:** General purpose sensor monitor
Design by M. Haas
42 **COURSE:** Figuring it out – Part 16: More about Fourier
By Owen Bishop
62 **PROJECT:** TV sound-to-light unit
From an idea by B. Willaert

RADIO, TELEVISION & COMMUNICATIONS

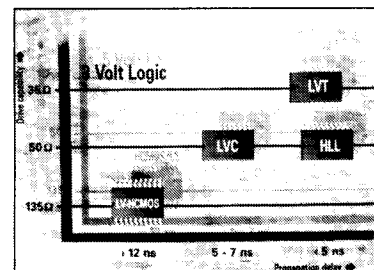
- 16 **PROJECT:** Morse decoder
Design by Velleman NV
52 Using the double balanced mixer
By Joseph J. Carr, BSc, MSEE

TEST & MEASUREMENT

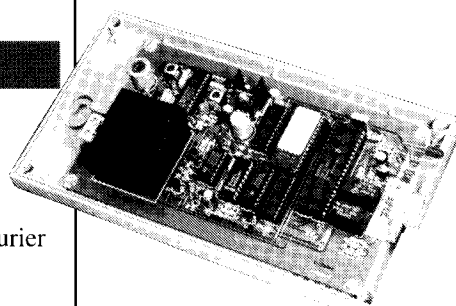
- 22 **PROJECT:** Differential probe for oscilloscopes
Design by H. Bonekamp
46 **PROJECT:** Low-voltage monitor
Design by J. Rutgers

MISCELLANEOUS INFORMATION

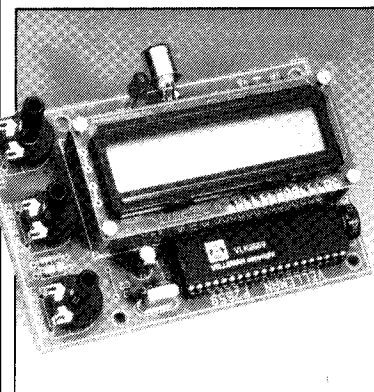
- 74 Buyers' guide
69 Component ratings
7 Credits
74 Index of advertisers
69 Letters
50 New books
68 Product/Industry news
70 Readers' services
67 Switchboard
72 Terms of Business



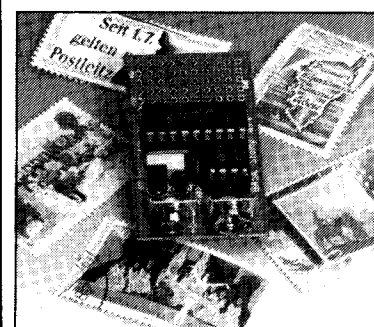
Low-voltage CMOS devices – p. 5



Mains signalling system – p. 10



Morse decoder – p. 16

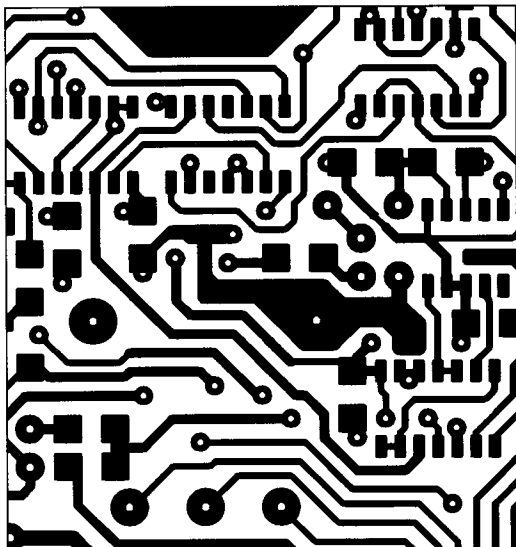


Stamp BASIC computer – p. 38

Elektor Electronics is published monthly, except in August, by Elektor Electronics (Publishing), P.O. Box 1414, Dorchester, Dorset DT2 8YH, England. The magazine is available from newsagents, bookshops, and electronics retail outlets, or on subscription at an annual (1994) post paid price of £27.00 in the United Kingdom; air speeded: £34.00 in Europe; £43.00 in Africa, the Middle East and South America; £45.00 in Australia, New Zealand and the Far East; and \$57.00 in the USA and Canada. Second Class Postage paid at Rahway N.J. Postmaster: please send address corrections to Elektor Electronics, c/o Mercury Airfreight International Ltd Inc., 2323 Randolph Avenue, Avenel, New Jersey, N.J. 07001.

EASY-PC, Schematic and PCB CAD

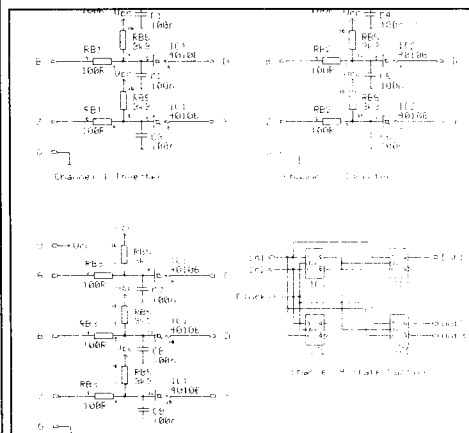
Over 18,000 Installations
in 80 Countries World-wide!



- Runs on:- PC/XT/AT/ 286/ 386/ 486 with Hercules, CGA, EGA or VGA display and many DOS emulations.
- Design:- Single sided, Double sided and Multi-layer (8) boards.
- Provides full Surface Mount support.
- Standard output includes Dot Matrix / Laser / Ink-jet Printer, Pen Plotter, Photo-plotter and N.C. Drill.
- Tech Support - free.
- Superbly easy to use.

**Still
Only
£98.00!**
Plus P&P+VAT

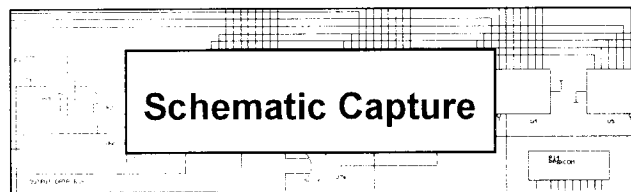
**BRITISH
DESIGN
AWARD
1989**



Options:-500 piece Surface Mount Symbol Library £48,
1000 piece Symbol Library £38, Gerber Import facility £98.

Electronic Designs Right First Time?

Integrated Electronics CAD



Prices from UK£195 / US\$375

Affordable Electronics CAD

EASY-PC: Entry level PCB and Schematic CAD.	\$195.00	£98.00
EASY-PC Professional: Schematic Capture and PCB CAD. Links directly to ANALYSER III and PULSAR.	\$375.00	£195.00
PULSAR: Digital Circuit Simulator ~ 1500 gate capacity.	\$195.00	£98.00
PULSAR Professional: Digital Circuit Simulator ~ 50,000 gate capacity.	\$375.00	£195.00
ANALYSER III: Linear Analogue Circuit Simulator ~ 130 node capability	\$195.00	£98.00
ANALYSER III Professional: Linear Analogue Circuit Simulator ~ 750 node capability.	\$375.00	£195.00
Z-MATCH for Windows: NEW Windows based Smith-Chart program for RF Engineers.	\$475.00	£245.00
We operate a no penalty upgrade policy. You can upgrade at any time to the professional version of a program just for the difference in price.		US\$ prices include Post and Packing.
		UK£ prices exclude P&P and VAT

For full information, please write, phone or fax:-

Number One Systems

UK/EEC: Ref. EK, HARDING WAY, ST. IVES, CAMBS., ENGLAND, PE17 4WR.

Telephone UK: 0480 461778 (7 lines) Fax: 0480 494042 International +44 480 461778

USA: Ref. EK, 1795 Granger Avenue, Los Altos, CA 94024

Telephone/Fax: (415) 968 9306

- TECHNICAL SUPPORT FREE FOR LIFE
- PROGRAMS NOT COPY PROTECTED.
- SPECIAL PRICES FOR EDUCATION.

ACCESS, MASTERCARD, VISA Welcome.

LOW-VOLTAGE CMOS DEVICES

By our editorial staff

One sector of the electronics market continues to demand faster and more powerful personal computers. Another demands a longer life from one battery charge in case of portable computers: 2–3 hours is now a minimum. Such demands are not restricted to computers: they apply equally to portable radio receivers, radio telephones and instrumentation equipment. At the same time, the world needs a more efficient use of energy. These conflicting demands force designers of electronic components to bring out ever faster, smaller and more energy-friendly devices. A logical consequence of this is that ICs are becoming smaller and smaller. This in turn means that their dissipation becomes a problem.

All these requirements have resulted in a lowering of the traditional 5-V supply voltage to 3.3 V (JEDEC standard for mains-operated equipment). Low-voltage versions of 80386 and 680x0 processors, memories, ASICs, disc controllers, LCD controllers, data converters and regulators are already available.

This article takes a closer look at a number of low-voltage families of CMOS logic devices from Philips. Each of these families has a unique product differentiator.

- LV-HCMOS is a 3.3 V medium-speed CMOS family that is compatible with LS and HCMOS.
- LVC is a 3.3 V CMOS logic family that is compatible with FAST, ACL, (Q)FACT and ALS.
- HLL is the world's fastest CMOS family with centre supply pinning and provid-

ing low skew, low EMI and a speed as FCT-C.

- ALVC is basically the Multi-byte™ version of HLL.
- LVT is a 3.3 V BiCMOS family that is optimized for driving backplanes and provides live insertion/auto three-state, bus hold and outputs that can handle forced 5 V. It is compatible with ABT, BCT and FCT-A.

All devices in these families operate from supplies of 1.2–3.6 V. Because of their low dissipation, these devices are eminently suitable for use in battery-operated equipment. Moreover, in view of their high speed, they are also a good choice in fast digital cir-

cuits.

Other advantages are that, because of the low supply voltage, noise levels are down and the reliability of the system increases (because of the lower mechanical stresses in the ICs).

Wide voltage range

Although JEDEC has standardized the supply voltage for mains-operated equipment at 3.3 V $\pm$ 0.3 V, this does not apply to battery-operated equipment. The problem there is the large variation of the battery voltage over the life of the battery. For instance, the e.m.f. of two series-con-

nected alkaline or carbon-zinc batteries at the end of their life is 1.8 V, while that of a NiCd battery is 1.2 V to just before it is fully discharged. Thanks to the wide range of operating voltages of the new devices, the use of dry as well as rechargeable batteries presents no problems.

Low voltage, same speed

As shown in Fig. 1, the speed of a logic component and the supply voltage from which it operates are related. The dynamic power dissipation (the static dissipation of CMOS devices is virtually nil) decreases roughly with the square of a reduction in supply voltage. Thus, an obvious method of reducing the dissipation of these circuits is a decrease of the nominal supply voltage. The relevant graph in Fig. 1 shows that the dissipation of a 3.3-V component is about 65% lower than that of a 5-V component, but is accompanied by a 20% reduction in speed. Thus, the immediate advantages of moving from 5-V to 3.3-V operation are that the speed/dissipation ratio is more than doubled, and it becomes possible to power CMOS logic from a 1-cell or 2-cell battery in portable equipment. The reduction of maximum speed may be negated, and even reversed, by the use of sub-micron technology.

LV-HCMOS family

The LV-CMOS logic family is based on HCMOS (HC) technology and is manufactured in a similar manner. Although developed primarily for operation from 3.3 V supplies, the components in this family can work with supply voltages ranging from 1.0 V to 3.6 V.

With a 3.3 V supply, the speed and performance are the same as HCMOS working from 5 V. There are, therefore, no disadvantages in replacing 5 V logic components with LV-HCMOS devices.

To obtain the same speed as available from 5-V CMOS components, the channel length of LV-HCMOS devices is reduced to 2 μ m, the gate oxide is thinner and the threshold voltages are lowered. Because of the reduced channel length, the propagation delay with a supply of 3.3 V is only 9 ns. With a supply voltage of 2 V, the output drive is 4 mA and even 6 mA for driver outputs. With a 3.3 V supply, outputs can drive loads $\geq$ 130 Ω .

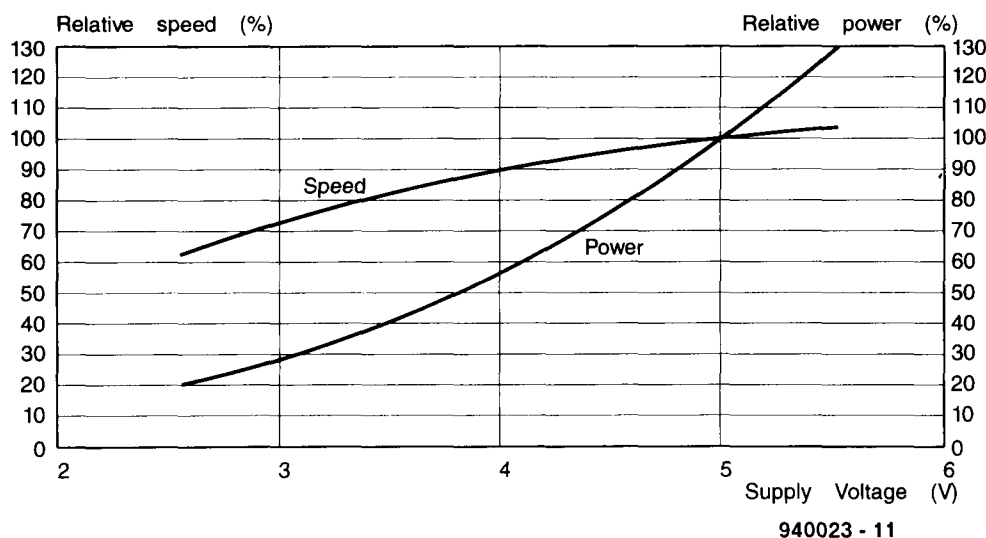
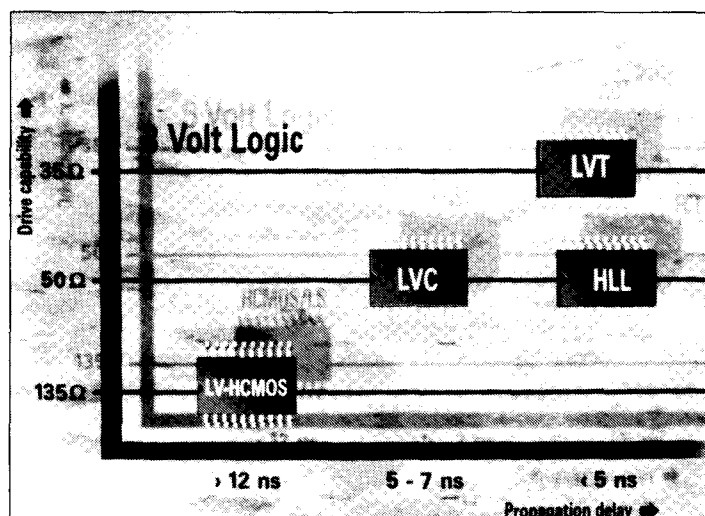


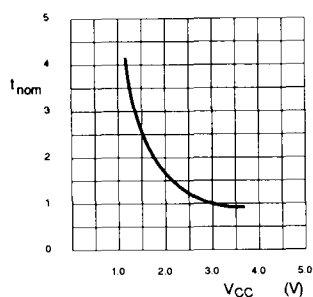
Fig. 1. Relation between supply voltage, speed and dissipation of logic components.

LVC family

The LVC family is compatible with the F(ast) CMOS series as far as speed, output drive characteristics and pinning are concerned. It is manufactured in 6 μm CMOS technology and thus dissipates much less power than F(ast) logic devices. Although designed for operation from a 3.3 V ± 0.3 V supply, the devices can be used with a supply voltage range of 1.2 V to 3.6 V, but they tend to slow down at the lower voltages. With a supply of 2 V, they provide a drive of up to 24 mA. With a 3.3 V supply, outputs can drive loads $\geq 50 \Omega$. Because of the sub-micron technology (0.6 μm), the propagation delay with a supply of 3.3 V is not greater than 6.5 ns. Since, with a supply of 3.3 V, the input levels may be as high as 5.5 V, this family is ideally suitable for use in 5 V to 3 V and 3 V to 5 V level shifting in mixed 3 V/5 V systems.

HLL family

The HLL family is a new logic family: the world's fastest 3.3 V logic ICs. The devices are manufactured in sub-micron (0.6 μm) CMOS technology that uses two-level metal and epitaxial substrates. HLL ICs operating from 3.3 V ± 0.3 V work at twice the speed of F(ast) bipolar logic. Since they are CMOS devices, they dissipate only a fraction of the power needed by bipolar components. The family is ideally suited for very high speed operation in data buses of mains-powered equipment. The sub-micron technology guarantees a propagation delay of not more than 4 ns with a 3.3 V supply. The high dynamic output drive allows transition times to be much shorter than the propagation delay. Outputs can drive loads $\geq 50 \Omega$. With a 3.3 V supply, the devices interface directly with TTL logic.



940023 - 12

Fig. 2. Propagation delay vs supply voltage characteristic.

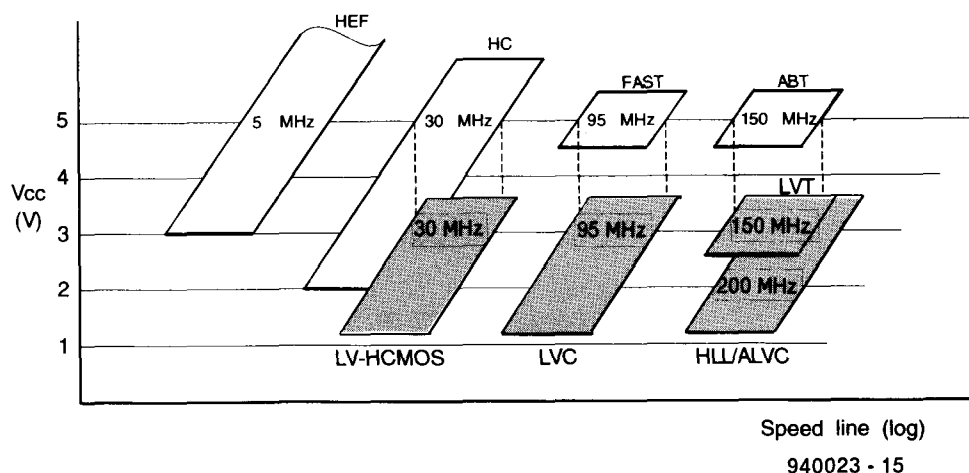


Fig. 3. Each logic family has its own operating area.

Key parameter/feature	LV-HCMOS	LVC	HLL/ALVC	LVT
Key parameters				
Nomenclature*	74LVxxxX	74LVCxxxX	74HLL33xxxX 74ALVC16xxxX	74LVTxxxX
Supply voltage range V	1.0 to 3.6	1.2 to 3.6	1.2 to 3.6	2.7 to 3.6
Output current I_{OH}/I_{OL} mA	6/6	24/24	24/24	32/64
Quiescent current μA	80	20	80/40	80
Typical propagation delay:				
data to output ns	9	4.0	2.1	2.4
output-enable to output ns	14	5.8	4.0	3.6
Max. ground bounce (V_{OLP}) V	0.5	0.8	1.0	0.8
Temperature range $^{\circ}\text{C}$	-40 to +125	-40 to +85	-40 to +85	-40 to +85
Features				
Full CMOS	✓	✓	✓	✓
Advanced BiCMOS				✓
Drive capability:	✓	✓	✓	✓
135 Ω				
50 Ω				
35 Ω				
Effective channel length:	✓	✓	✓	✓
2.0 μm				
0.8 μm				
0.6 μm				
Corner supply pins	✓	✓	✓	✓
Centre supply pins			✓	
TTL level input	✓	✓	✓	✓
TTL level output	✓	✓	✓	✓
5 V input capability		✓**	✓**	✓
Forced 5 V output				✓
Live insertion				✓
Input bus hold				✓
Packages:				
DIL	✓	✓	✓/-	✓
SO	✓	✓	✓/-	✓
SSOP	✓	✓	✓/-	✓
TSSOP	✓	✓	✓/-	✓
Application:				
glue logic	✓	✓	✓	✓
battery-powered equipment	✓	✓	✓	✓
local bus		✓	✓	✓
super μP			✓	✓
backplane				✓
Compatible 5 V families	LS-TTL HC/HCT N74xx	FAST ACL(Q)FACT ALS	FCT-C	ABT BC/BCT FCT-A
Product differentiator	3 V equivalent of LS/HC	3 V equivalent of FAST	world's fastest logic	3 V equivalent of ABT; optimized for backplanes

* xxx = 245 etc, X = package code: D = SO, DB = SSOP II, PW = TSSOP I, DL=SSOP 48-56, DGG=TSSOP 48-56

** For transceivers $V_{IN\max} = V_{CC} + 0.5$ V.

Table 1. Main parameters of the low-voltage CMOS logic families.

Produced and published by **ELEKTOR ELECTRONICS (Publishing)**

Editor/publisher: Len Seymour
Technical Editor: J. Buiting

Editorial & Administrative Offices:
P.O. Box 1414
DORCHESTER DT2 8YH
England
Telephone: (0305) 250 995 (National)
or +44 305 250 995 (International)
Fax: (0305) 250 996 (National)
or +44 305 250 996 (International)

U.K. Advertising Office:
3 Crescent Terrace
CHELTENHAM GL50 3PE
Telephone: (0242) 510 760
Fax: (0242) 226 626

International Advertising Office:
Elektuur BV
P.O. Box 75
6190 AB BEEK
The Netherlands
Telephone: +31 46 38 94 44
Fax: +31 46 37 01 61

Subscriptions:
World Wide Subscription Service Ltd.

Unit 4, Gibbs Reed Farm
Pashley Road
TICEHURST TN5 7HE
Telephone: (0580) 200 657 (National)
or +44 580 200 657 (International)
Fax: (0580) 200 616 (National)
or +44 580 200 616 (International)

Head Office:
P.O. Box 75
6190 AB BEEK
The Netherlands
Telephone: +31 46 38 94 44
Telex: 56617 (elekt.nl)
Fax: +31 46 37 01 61
Managing Director: M.M.J. Landman

Distribution:
SEYMOUR
1270 London Road
LONDON SW16 4DH

Printed in the Netherlands by NDB,
Zoeterwoude

Overseas editions:
FRANCE
Elektor sarl
Les Trois Tilleuls
B.P. 59; 59850 NIEPPE
Editor: G.C.P. Raedersdorf

GERMANY
Elektor Verlag GmbH
Süsterfeld Straße 25
5100 AACHEN
Editor: E.J.A. Krempelsauer

GREECE
Elektor EPE
Kariskaki 14
16673 Voula—ATHENA
Editor: E. Xanthoulis

HUNGARY
Elektor Elektronikai folyóirat
1015 Budapest
Batthyány u. 13
Editor: Lakatos András

INDIA
Elektor Electronics PVT Ltd
Chhotani Building
52C, Proctor Road, Grant Road (E)
BOMBAY 400 007
Editor: C.R. Chandarana

ISRAEL
Elektorcal
P O Box 41096
TEL AVIV 61410
Publisher: M. Avraham

NETHERLANDS
Elektuur BV
Peter Treckpoelstraat 2-4
6191 VK BEEK
Editor: P.E.L. Kersemakers

POLAND
Elektor Elektronik
02-777 Warszawa 130
Skrytka Poczтовая 271
Editor: W. Marciniak

PORTUGAL
Ferreira & Bento Lda.
R.D. Estefani, 32-1°
1000 LISBOA
Editor: F. Ferreira de Almeida

SPAIN
Resistor Electronica Aplicada
Calle Maudes 15 Entlo C.
28003 MADRID
Editor: Agustin Gonzales Buelta

SWEDEN
Electronic Press AB
Box 5505
14105 HUDDINGE
Editor: Bill Cedrum

LVT family

The low-voltage BiCMOS logic family is manufactured in 0.8 μm QUBiC technology to combine the best properties of CMOS with

the best of bipolar devices. This results in very high output current and very high speed without compromise of dissipation or noise levels. The outputs can deliver cur-

rents of up to 32 mA and sink currents of up to 64 mA. They can drive loads $\geq 35 \Omega$ directly. The QUBiC technology guarantees propagation delays of not greater

than 4 ns with a supply of 3.3 V. The devices may be used in mixed 3 V/5 V systems.

END

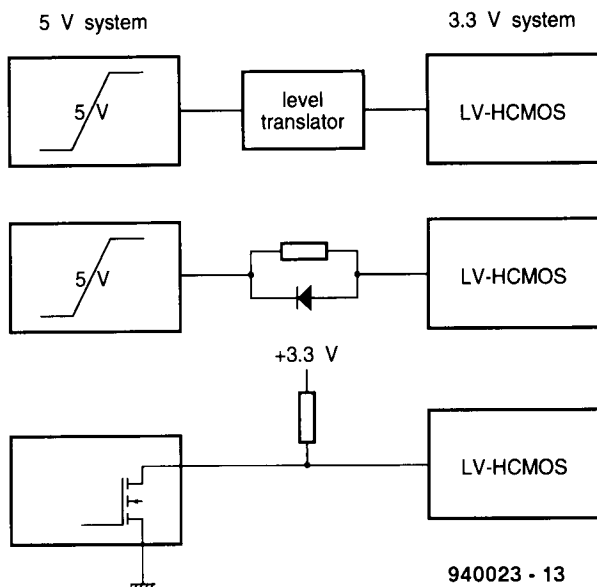


Fig. 4. Various methods of linking traditional 5-V logic devices and low-voltage logic devices.

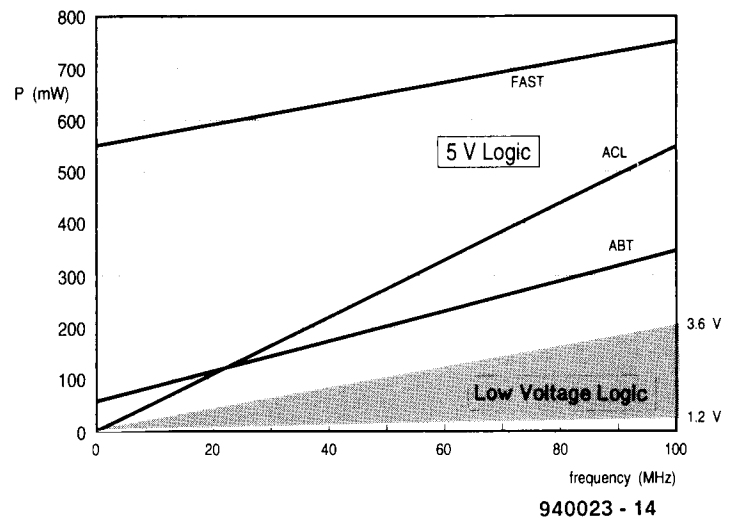


Fig. 5. Dissipation vs frequency characteristics of the various logic families.



VICOM

TEL 081-471 9338 TLX 929709 VICOM G FAX 081-552 0946

DIGITAL INTEGRATED CIRCUIT SPECIALIST

4000 SERIES	4513B	1.20	4016BT	0.43	74160	0.94	74LS169	0.59	74LS669	1.00
4000B 0.16	4514B	1.20	4017BT	0.78	74161A	0.98	74LS170	POA	74LS670	1.00
4000UB 0.16	4515B	1.12	4018BT	0.78	74163	1.28	74LS173	0.39	74LS673	POA
4001A 0.16	4516B	0.44	4020BT	0.95	74164	1.20	74LS173A	0.44	74LS674	17.00
4001B 0.16	4517B	1.84	4021BT	0.65	74165	1.57	74LS174	0.36	74LS682	2.00
4001UB 0.22	4518B	0.40	4023BT	0.38	74166	1.06	74LS175	0.34	74LS683	POA
4002B 0.18	4519B	0.36	4024BT	0.76	74171	1.53	74LS181	1.82	74LS684	POA
4002B 0.18	4520B	0.36	4025BT	0.38	74175	1.23	74LS182	2.20	74LS685	POA
4006B 0.39	4521B	0.86	4026BT	0.56	74180	1.93	74LS183	0.05	74LS686	POA
4007UB 0.20	4522B	0.86	4028BT	0.56	74184	POA	74LS189	2.60	74LS687	POA
4008B 0.40	4525B	0.50	4029BT	0.86	74185	1.76	74LS190	0.49	74LS688	1.00
4009AE 0.23	4527B	0.56	4040BT	0.78	74191	1.41	74LS191	0.49	74LS693	POA
4009B 0.23	4528B	0.49	4042BT	0.74	74192	1.41	74LS192	0.49	74LS794	POA
4010B 0.18	4529B	0.57	4046BT	1.00	74193	1.65	74LS193	0.48	74LS795	POA
4011B 0.29	4530B	1.92	4047BT	1.06	74221	1.23	74LS194	0.54	74LS796	POA
4011UB 0.29	4531B	1.14	4049BT	1.06	74229	2.92	74LS194A	0.57	74LS797	POA
4012A 0.16	4532B	0.44	4050BT	0.48	74265	1.46	74LS195A	0.57	74LS84B	POA
4012B 0.20	4534B	2.82	4051BT	0.78	74273	POA	74LS196	0.68		
4013B 0.20	4535B	0.40	4052BT	0.84	74276	1.38	74LS196A	0.68		
4014B 0.42	4536B	0.60	4053BT	0.98	74279	1.38	74LS221	0.40	74HC00	0.00
4015B 0.42	4539B	0.62	4060BT	0.84	74283	1.26	74LS224	20.24	74HC02	0.00
4016B 0.24	4541B	0.52	4066BT	0.59	74298	POA	74LS240	0.42	74HC03	0.00
4017B 0.38	4543B	0.57	4068BT	0.38	74365	0.70	74LS241	0.42	74HC04	0.00
4018B 0.38	4544B	2.11	4069UBT	0.38	74367	1.06	74LS242	0.42	74HC04	0.00
4019B 0.26	4547B	1.68	4070BT	0.38	74393	2.94	74LS243	0.42	74HC05	0.00
4020AE 0.26	4549B	POA	4071BT	0.38	74403	POA	74LS244	0.42	74HC08	0.00
4020B 0.16	4551B	1.62	4075BT	0.38	74423	POA	74LS245	0.42	74HC11	0.00
4021B 0.40	4553B	2.37	4077BT	0.38			74LS247	0.44	74HC12	0.00
4022B 0.40	4554B	6.01	4078BT	0.38			74LS250	0.44	74HC14	0.00
4023B 0.20	4556B	4.01	4079BT	0.38			74LS251	0.44	74HC14A	0.00
4023UB 0.20	4556B	4.01	4079BT	0.38			74LS251	0.44	74HC14A	0.00
4024AE 0.27	4557B	1.88	4094BT	0.95	74LS00	0.18	74LS251	0.32	74HC20	0.00
4024B 0.32	4558B	2.18	4096BT	2.05	74LS01	0.18	74LS253	0.44	74HC21	0.00
4025B 0.19	4560B	1.51	4510BT	1.02	74LS02	0.18	74LS256	0.78	74HC27	0.00
4026B 0.54	4561B	1.74	4511BT	1.35	74LS03	0.21	74LS257A	0.46	74HC30	0.00
4027B 0.30	4562B	5.15	4512BT	0.68	74LS05	0.21	74LS258	0.44	74HC42	0.00
4028B 0.38	4566B	1.10	4514BT	2.20	74LS06	0.51	74LS258A	0.48	74HC58	0.00
4029B 0.38	4568B	5.17	4516BT	1.02	74LS07	0.51	74LS259	0.48	74HC73	0.00
4030B 0.21	4569B	3.04	4518BT	1.18	74LS08	0.18	74LS260	0.22	74HC74	0.00
4031B 1.04	4573B	POA	4521BT	1.07	74LS10	0.18	74LS273	0.42	74HC75	0.00
4032B 0.70	4580B	8.84	4522BT	1.22	74LS11	0.18	74LS275	POA	74HC76	0.00
4033B 0.58	4581B	3.85	4528BT	0.88	74LS12	0.18	74LS279	0.33	74HC77	0.00
4034B 1.10	4582B	3.85	4534BD	POA	74LS13	0.19	74LS280	0.86	74HC85	0.00
4035B 0.39	4583B	0.56	4538BT	1.05	74LS14	0.28	74LS283	0.45	74HC86	0.00
4036B 2.57	4584B	0.87	4541BT	1.05	74LS15	0.38	74LS290	0.48	74HC93	0.00
4038B 0.78	4585B	4.49	4543BT	1.02	74LS20	0.18	74LS292	16.86	74HC107	0.00
4039B 0.78	4597CP	0.90	4555BT	POA	74LS21	0.18	74LS293	0.38	74HC112	0.00
4040B 0.42	4598B	6.90	4556BT	0.18	74LS22	0.18	74LS294	1.77	74HC113	0.00
4041UB 0.32	4599B	5.50	4557BT	0.95	74LS24	0.58	74LS295	18.82	74HC123	0.00
4042B 0.36	4601B	0.40	4010BT	0.53	74LS26	0.18	74LS295A	1.15	74HC125	0.00
4043B 0.36	4720B	POA	4024BT	2.35	74LS28	0.18	74LS298	0.98	74HC125	0.00
4044B 0.36	4723B	POA	4037BT	1.34	74LS32	0.24	74LS299	1.53	74HC126	0.00
4044B 0.36	4724B	1.90			74LS31	0.18	74LS321	3.82	74HC131	0.00
4045B 0.94	4731VP	9.80	74 SERIES		74LS31	1.58	74LS322	POA	74HC132	0.00
4046B 0.42	4737VP	18.28			74LS32	0.20	74LS322A	POA	74HC133	0.00
4047B 0.38	4738VP	18.50	7400	0.36	74LS33	0.20	74LS323	3.24	74HC137	0.00
4048B 0.42	4750VD	28.50	7401	0.30	74LS37	0.18	74LS347	2.86	74HC139	0.00
4049B 0.28	4752VP	29.25	7402	0.34	74LS38	0.18	74LS348	1.98	74HC141	0.00
4049UB 0.28	4753VP	POA	7403	0.34	74LS40	0.18	74LS352	1.68	74HC147	0.00
4050B 0.22	4754VP	POA	7404	0.34	74LS41	0.18	74LS353	1.68	74HC147	0.00
4051B 0.34	4005B	1.98	7405	0.40	74LS44	2.11	74LS363	2.10	74HC148	0.00
4052B 0.33	4009B	0.62	7406	0.68	74LS47	0.55	74LS364	POA	74HC151	0.00
4053B 0.34	4009B	0.62	7406A	0.72	74LS48	0.54	74LS385	0.30	74HC153	0.00
4054B 0.68	4010B	2.48	7407	0.63	74LS49	1.38	74LS365A	0.34	74HC154	0.00
4055B 0.62	4010B	POA	7407A	0.65	74LS51	0.19	74LS366	0.36	74HC155	0.00
4056B 0.48	40102	1.20	7408	0.37	74LS52	0.19	74LS366A	0.42	74HC157	0.00
4057B 0.38	40103	0.88	7409	0.67	74LS54	0.32	74LS367	0.29	74HC160	0.00
4058B 0.38	40105	1.82	7410	0.35	74LS73	0.40	74LS367A	0.34	74HC161	0.00
4063B 0.42	40106	0.30	7412	0.64	74LS73A	0.48	74LS368	0.36	74HC162	0.00
4066B 0.27	40107	0.30	7413	0.64	74LS74	0.48	74LS369	0.36	74HC163	0.00
4067B 1.85	40108	POA	7414	0.72	74LS74A	0.24	74LS373	0.38	74HC164	0.00
4068B 0.26	40109	1.24	7416	0.53	74LS75	0.28	74LS374	0.44	74HC165	0.00
4069UB 0.21	40110	0.34	7417	0.48	74LS76	0.68	74LS375	0.42	74HC165	0.00
4070B 0.21	40114	2.62	7420	0.37	74LS76A	0.72	74LS377	0.66	74HC166	0.00
4071B 0.20	40116	12.48	7423	0.59	74LS78	0.42	74LS378	0.98	74HC173	0.00
4072B 0.20	40117	1.80	7426	0.48	74LS78B	0.32	74LS379	0.99	74HC174	0.00
4073B 0.19	40147	1.23	7427	0.59	74LS83	0.39	74LS381A	4.96	74HC189	0.00
4075B 0.19	40160	0.54	7430	0.35	74LS83A	0.39	74LS385	3.48	74HC182	0.00
4076B 0.42	40161	0.54	7432	0.45	74LS86	0.38	74LS386	0.98	74HC190	0.00
4077B 0.20	40162	0.20	7437	0.49	74LS87	0.38	74LS387	0.98	74HC191	0.00
4078B 0.21	40163	0.54	7438	0.48	74LS90	0.40	74LS393	0.44	74HC192	0.00
4081B 0.18	40174	0.34	7440	0.77	74LS91	POA	74LS395	0.66	74HC193	0.00
4082B 0.20	40175	0.47	7442	0.55	74LS92	POA	74LS395A	0.94	74HC194	0.00
4085B 0.38	40181	POA	7445	1.20	74LS93	0.44	74LS396	POA	74HC195	0.00
4086B 0.38	40192	0.62	7446	1.53	74LS95	0.48	74LS398	POA	74HC221	0.00
4089B 0.59	40193	0.74	7447	0.98	74LS96	0.82	74LS399	0.81	74HC223	0.00
4093B 0.24	40194	1.82	7447A	1.67	74LS107	0.28	74LS423	0.98	74HC258	0.00
4094B 0.24	40195	2.24	7451	0.57	74LS107A	0.38	74LS445	POA	74HC260	0.00
4095B 0.70	40240	2.62	7454	0.72	74LS109	0.28	74LS540	10.68	74HC240	0.00
4096B 1.10	40244	1.36	7470	0.54	74LS109A	0.32	74LS461A	7.16	74HC241	0.00
4097B 2.75	40247	0.20	7472	0.64	74LS110	0.32	74LS461B	7.16	74HC242	0.00
4098B 0.40	40257	0.54	7473	0.59	74LS112A	0.34	74LS467	7.78	74HC243	0.00
4099B 0.42	40373	1.10	7474	0.53	74LS113	0.32	74LS468	7.78	74HC244	0.00
4104P 0.01	40374	1.10	7475	0.67	74LS113A	0.38	74LS469	6.10	74HC245	0.00
4160B 0.85	45026	4.42	7476	0.72	74LS114	0.32	74LS469A	6.70	74HC251	0.00
4161B 0.85	45027	5.99	7480	1.26	74LS114A	0.36	74LS490	2.85	74HC293	0.00
4174B 1.27	45028	4.49	7483	1.10	74LS122	0.39	74LS491A	12.82	74HC257	0.00
4194B 1.43	45040	POA	7485	0.58	74LS123	0.36	74LS502	POA	74HC258	0.00
4409P 1.05	45041	POA	7486	0.53	74LS125	0.28	74LS540	0.80	74HC266	0.00
4410P 16.45	45100	POA	7490	0.76	74LS125A	0.32	74LS541	0.80	74HC273	0.00
4411P 21.58	45109	POA	7491	2.56	74LS126A	0.36	74LS542	1.34	74HC279	0.00
4412FP POA	45138	POA	7492	0.67	74LS132	0.29	74LS573	0.44	74HC280	0.00
4412FL POA	45145	10.04	7493	1.12	74LS133	0.18	74LS590	4.85	74HC283	0.00
4419P POA	45146	POA	7493A	0.68	74LS136	0.38	74LS592	5.28	74HC298	0.00
4419F POA	45151	19.50	7493A	1.70	74LS137	0.98	74LS593	6.79	74HC299	1.00
4423PB POA	45152	21.45	7495A	1.10	74LS138	0.31	74LS595	4.85	74HC323	1.00
4434P POA	45156	15.80	7497	5.23	74LS139	0.34	74LS597	4.95	74HC354	0.00
4443P POA	45157	14.38	74104	0.67	74LS145	0.66	74LS621	POA	74HC365	0.00
4447P POA	45158	1.94	74107	0.80	74LS147	2.8				

MICROPROCESSOR & SUPPORT ICs		HDI-0165-5		SAB8155-P		TL1100		ICL7611 DCPA		LM340TS		NE536H		TL071CP		75 SERIES		BC182		BFW10	
100114DEC	7.40	HD14681BAP	4.20	SAB8259AP	5.59	TL1100	0.60	ICL7622 DCPA	0.60	LM340TS	0.80	NE536H	0.80	TL071CP	0.64	75107	1.02	BC182A	0.06	BFW10	1.20
100141DC	9.80	HD3-6400-9	6.16	SAB8255A-2-P	4.12	TL1113	0.85	ICL7650 CDP	0.98	LM346D	0.96	NE5532AN	1.56	TL072CN	0.50	75107A	1.02	BC182B	0.06	BFX48	0.49
63030XP	8.76	HD3-6495-9	8.89	SC8082A1cm6413.60	8.89	TL1119	1.20	ICL7650SCDP	6.24	LM348N	0.40	NE5534AN	1.80	TL072CP	0.50	75108	1.80	BC182L	0.06	BFX85	0.59
4321P	9.76	HD44883	9.52	SCN2661bcm283.35	9.52	TL1311	0.95	ICL7652BCPD	8.27	LM350T	0.65	NE555AN	0.20	TL074CN	0.85	75108A	1.84	BC182LB	0.06	BFX88	0.30
63485CP32/sm	19.95	HD46505SP	9.50	SCN2661cm28	3.35	TLP504A	1.58	ICL7652CPD	8.24	LM351N	0.20	NE556S/MD	0.70	TL081CP	0.48	75109A	2.46	BC183C	0.06	BFY50	1.59
63303XP	10.97	HD46802P	9.50	PAL1.6RA-15CN	2.98	TLPS21-4GB	4.20	ICL7660CPA	1.40	LM358N	0.32	NE556N	0.38	TL082CP	0.48	75110A	1.36	BC183L	0.06	BFY90	0.34
6502	3.98	HD6321P	4.20	TL16C552FN	12.58	TORX173	4.96	ICL7660SCPA	3.80	LM359N	0.48	NE558N	2.28	TL084CN	0.48	75111A	3.02	BC184C	0.06	BS107	0.28
6502A	3.98	HD63486P/32	32.50	TM71002NL	2.40	TOTX173	4.96	ICL7662CPA	4.40	LM360H	7.72	NE564N	3.48	TL27L2C/MD	1.98	75114	3.04	BC184B	0.06	BS170	0.28
6520P	4.40	HD638303X	11.95	TM7068AP-2	4.97	741-OPAMP	0.18	ICL7663BCJA	7.78	LM361MSMD	6.40	NE565N	2.94	TL27L2C/MD	3.44	75115	3.02	BC184L	0.06	BS250	0.52
6522	4.40	HD68000-9	1.59	TMS3477NL	6.68			ICL7663BCPD	6.98	LM363DN	16.50	NE568N	0.04	TL507CP	4.03	75116	1.30	BC184C	0.06	BS252	0.52
6522A	5.26	HD6845SP	6.92	TMS3700NSB	8.78			ICL7664CPA	5.95	LM369DN	3.20	NE570N	4.60	TL702ACP	2.04	75121	2.60	BC184C	0.06	BS260	0.48
6551	4.43	HD68821P	4.29	TMS3702ANS	8.78	3630BM/BB	3.40	ICL7665ACPA	1.98	LM369DCR	1.30	NE570N	4.60	TL705ACP	2.04	75122	2.60	BC184C	0.06	BS262	0.48
6551A	4.43	HD68821P	4.29	TMS3835ANS	7.55	49620/BB	3.40	ICL7673CPA	1.98	LM380N	1.20	NE571N	3.20	TL705CP	2.04	75123	2.60	BC184C	0.06	BS262	0.48
65C02P2	5.84	HI3-7159-5	20.98	TMS7700NL	10.74	S55-TIMER	0.20	ICL8052ACPD	8.73	LM381AN	7.88	NE589N	4.25	TL709ACP	2.04	75124	2.60	BC184C	0.06	BS262	0.48
65C02P3	6.94	HI3-7159-5	23.40	TMS9900NL	24.40	ICL7684AJD	11.38	ICL8056AJD	11.38	LM385Z-1.2	2.20	NE592Z/MD	1.20	TL7770-SC	3.82	75125	2.60	BC184C	0.06	BS262	0.48
65C102P2	7.00	HI10422	14.30	TMS9901NL	14.16	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM385Z-2.5	2.20	NE592Z	1.20	TL7830CPL	5.10	75126	2.60	BC184C	0.06	BS262	0.48
65C12P2	4.80	HM282C86H	17.06	TMS9902ANL	15.16	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75127	2.60	BC184C	0.06	BS262	0.48
65C15E-1	4.80	IM6402A1P/L	10.20	TMS9902ANL	15.16	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75128	2.60	BC184C	0.06	BS262	0.48
65C15E-2	4.38	IM6402P/L	7.75	TMS9902ANL	15.16	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75129	2.60	BC184C	0.06	BS262	0.48
68000P-16	18.98	IMS2600P-15	4.40	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75130	2.60	BC184C	0.06	BS262	0.48
68000P-8	6.50	IMS2600P-15	4.40	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75131	2.60	BC184C	0.06	BS262	0.48
6800P-8	7.85	IMS2600P-15	4.40	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75132	2.60	BC184C	0.06	BS262	0.48
68010P-12	3.40	IMS2600P-15	4.40	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75133	2.60	BC184C	0.06	BS262	0.48
6802P	3.40	IMS2600P-15	4.40	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75134	2.60	BC184C	0.06	BS262	0.48
6803AP	3.40	IMS2600P-15	4.40	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75135	2.60	BC184C	0.06	BS262	0.48
68053E	10.98	IMS2600P-15	4.40	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75136	2.60	BC184C	0.06	BS262	0.48
6810P	3.40	IMS2600P-15	4.40	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75137	2.60	BC184C	0.06	BS262	0.48
6821P	1.52	MC10115P	1.98	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75138	2.60	BC184C	0.06	BS262	0.48
6840P	17.20	MC146805E2P	9.18	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75139	2.60	BC184C	0.06	BS262	0.48
6844P	4.86	MC6800P12/16	POA	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75140	2.60	BC184C	0.06	BS262	0.48
6845P	4.86	MC68010P10/12	POA	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75141	2.60	BC184C	0.06	BS262	0.48
6845SP	5.40	MC6802P	2.47	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75142	2.60	BC184C	0.06	BS262	0.48
68A00P	4.30	MC6809P	6.28	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75143	2.60	BC184C	0.06	BS262	0.48
68A09P	4.30	MC6821P	1.80	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75144	2.60	BC184C	0.06	BS262	0.48
68A21P	2.98	MC6840P	1.98	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75145	2.60	BC184C	0.06	BS262	0.48
68A50P	2.98	MC6845P	7.38	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75146	2.60	BC184C	0.06	BS262	0.48
68B09P	2.98	MC6850P	3.35	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75147	2.60	BC184C	0.06	BS262	0.48
68B21P	1.98	MC68705R3P	25.35	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75148	2.60	BC184C	0.06	BS262	0.48
68B40P	2.98	MC68A00P	7.02	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75149	2.60	BC184C	0.06	BS262	0.48
68BDA	2.98	MC68A09P	7.62	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75150	2.60	BC184C	0.06	BS262	0.48
8085AH-2	5.98	MC68314P	6.60	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75151	2.60	BC184C	0.06	BS262	0.48
8086-2	3.90	MC68610P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75152	2.60	BC184C	0.06	BS262	0.48
80C286-12/pga	48.50	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75153	2.60	BC184C	0.06	BS262	0.48
80C286-8/tpic	24.90	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75154	2.60	BC184C	0.06	BS262	0.48
80C85A-2	5.94	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75155	2.60	BC184C	0.06	BS262	0.48
80C85A-2	5.94	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75156	2.60	BC184C	0.06	BS262	0.48
80C85A-2	5.94	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75157	2.60	BC184C	0.06	BS262	0.48
80C85A-2	5.94	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75158	2.60	BC184C	0.06	BS262	0.48
80C85A-2	5.94	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75159	2.60	BC184C	0.06	BS262	0.48
80C85A-2	5.94	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75160	2.60	BC184C	0.06	BS262	0.48
80C85A-2	5.94	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830CPL	5.10	75161	2.60	BC184C	0.06	BS262	0.48
80C85A-2	5.94	MC68810P	3.00	UAE963ACP	1.98	ICL8069CCSQ	3.75	ICL8069CCSQ	3.75	LM388M-1/MD	1.65	NE592N14	0.92	TL7830C							

MAINS SIGNALLING SYSTEM

PART 2: TRANSMITTER

Design by W. Hackländer & S. Furchtbar

Mains signalling is a method by which signals can be superimposed on mains wiring for the remote control of electrical equipment. It was first proposed by two Swiss inventors, Routin and Brown, who patented the method to control street lighting in 1896. The technique is well established and accepted in the USA, but in this country and Europe interest in it as a medium for communication has begun only in the late 1980s. This article deals with a system for use in home automation. The main advantages of the system are ease of installation, flexibility and relatively low cost (because it uses existing mains wiring).

Since the transmitter is provided with a microprocessor, the command computer need only send simple instructions. These are translated by the transmitter into switching codes for specific receivers. At the same time, the transmitter arranges for the status of each receiver to be sent back to the computer. Communication between the transmitter and computer is via a standard RS232 link.

The circuit

Several sections of the circuit—see **Fig. 9**—are identical to parts of the receiver circuit. For instance, modulating and demodulating of the digital signals that are transferred via the mains wiring are again effected by an NE5050. Capacitors C_{15} and C_{16} and transformer Tr_2 form part of a 110 kHz transmit oscillator, whose carrier is switched on and off by the digital signal generated by IC_{7c} . The output signal is supplied via R_{21} and R_{22} to L_1 (which provides harmonics suppression), R_{20} (which provides impedance matching), and C_{12} (which provides d.c. decoupling). From there, the signal is applied to transformer Tr_1 which is linked to the mains wiring via C_{14} . Capacitor C_{13} and the transformer form a band-pass filter with a centre frequency of 110 kHz.

At the demodulating end, the level of the incoming signal (at pin 20) is limited by D_6 and D_7 , which also suppress any spurious signals. In the IC, the signal is applied to an amplifier, to a band-pass filter, Tr_3 - C_6 , a low-pass filter, C_{11} , an AM suppressor, a comparator and a bistable. Finally, it is available at pin 11.

The power supply is conventional: a mains transformer, Tr_4 , bridge rectifier, D_8 - D_{11} , buffer capacitor, C_{18} , and two regulators, IC_{11} and IC_{12} . The first regulator, IC_{11} , provides a direct voltage of 12 V, from which IC_{12} derives a direct voltage of 5 V. Moreover, a direct voltage of 9 V (for the decoder/encoder, IC_1) is provided by R_{11} - D_3 .

Circuit IC_4 is a miniature control sys-

tem with a clock frequency of 12 MHz (derived from crystal X_1).

Circuit IC_5 organizes the addresses on the multiplexed address/data lines PO_0 - PO_7 .

The control program for the transmitter is contained in EPROM IC_6 .

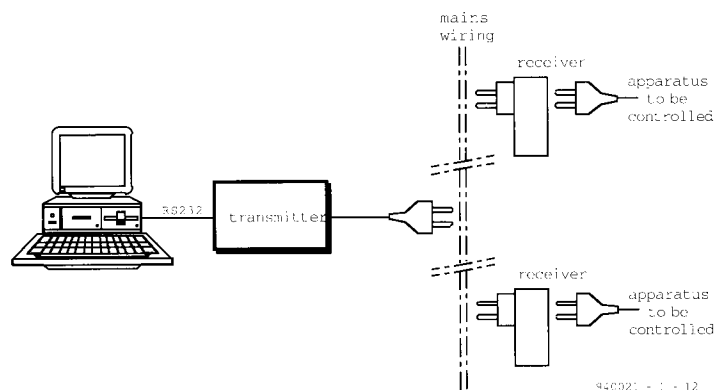
Optoisolators IC_8 and IC_9 connected to pins 10 and 11 of IC_4 effect the communication between the transmitter and computer via the serial interface. They are necessary to ensure proper electrical isolation between the transmitter and equipment connected to the RS232 interface, since transformer Tr_1 does not provide this. Circuit IC_8 passes the data received from the computer to IC_4 , while IC_9 sends data from IC_4 to the computer.

Network D_1 - R_3 at pin 12 of IC_4 serves to indicate confirmation of receipt of data. This interrupt input is controlled by T_1 .

The LED at pin 15 of IC_4 lights during the transmission of data. Output T_0 switches NAND gate IC_{7d} via T_2 .

The data for the receivers are sent over lines $P1.0$ - $P1.7$.

Coding and decoding of the receiver addresses are carried out by IC_1 . Network R_1 - C_1 sets the internal clock of this IC to 45 kHz. When the address of a given receiver is sent, the relevant data are available at the $P...$ gates of IC_4 , from where they are applied to IC_1 via buffer IC_3 and level compensator/inverter IC_2 .



Setup of a 2-receiver system. Up to 127 receivers may be accommodated.

Circuit IC_7 and transistors T_1 - T_3 ensure the correct switching sequence during transmitting and receiving. If, for instance, a receiver needs to be switched over, the processor provides the correct address at $P1$ and, via pin 14, gives the instruction for this address to be sent. Transistor T_2 raises the level from 5 V to 9 V and inverts the signal. The output of IC_{7d} then goes high, whereupon T_3 conducts, so that the output signal of the modem IC is suppressed to prevent IC_1 receiving back its own data during transmission.

NAND gate IC_{7d} sets IC_1 to the transmit mode via its mode input and enables IC_{7b} . The serial data then becoming available at pin 17 of IC_1 are passed via IC_{7b} and IC_{7c} to IC_{10} , where they are modulated and applied to the mains wiring. The code is transmitted several times in succession, which is indicated by the flickering of D_2 , while D_1 lights permanently.

After about 15 seconds, output T_0 of the processor goes low, which causes IC_1 to switch from transmit to receive (mode input goes low, IC_{7b} is disabled, and T_3 switches off, so that the signals received by IC_{10} are applied to pin 16 of IC_1). Two addresses monitor whether the slave reacts: that just transmitted and this address plus a '1' in the tenth position, from which the switching status of the receiver

becomes clear.

When, within a given period, a valid address is received four times, pin 17 of IC₁ goes low. This signal is passed to pin 12 of IC₄ via inverter IC_{7a} and level compensator/inverter T₁. This is indicated by D₁ going out. Confirmation of receipt of the data is then given to the computer by IC₄.

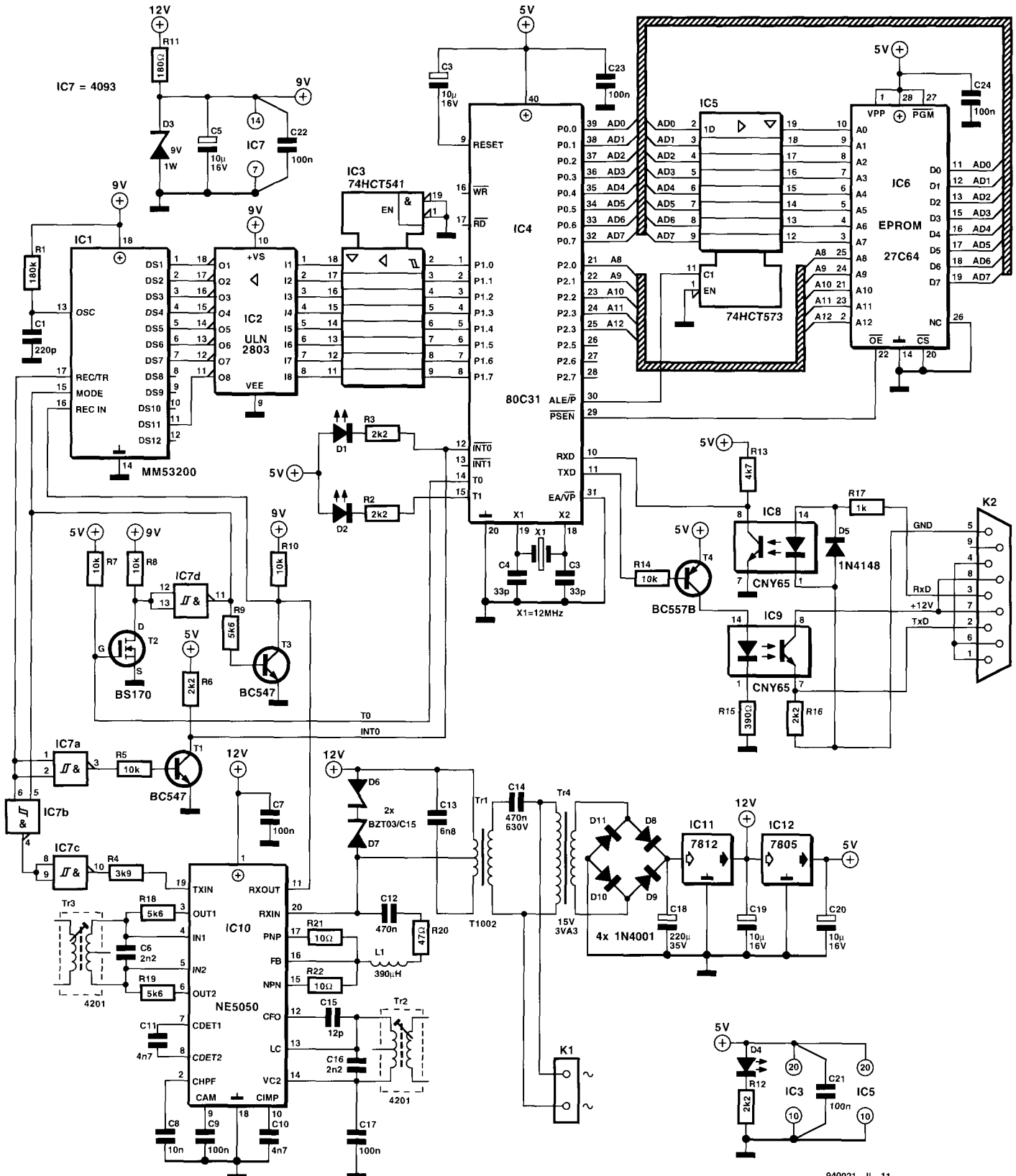
Construction

Building the transmitter is simpler than the receiver. All components are housed on a generously sized printed-circuit board, which, for safety's sake, is intended for installation in a man-made fibre enclosure. The use of sockets for the ICs is recommended: this is not only convenient for the construction but also for the cal-

ibration.

Screw the backs of regulators IC₁₁ and IC₁₂ together with in between a U-shaped heat sink. They need not be isolated.

Provide holes in the top of the enclosure for K₂ and the three 5-mm LEDs (for safety's sake, do not use 3-mm types because these may protrude from the enclosure). Provide a hole in one of the shorter



940021 - II - 11

Fig. 9. Circuit diagram of the mains signalling transmitter.

side for mains cable (use a strain relief) entry.

Do not yet place the ICs into their sockets; this should be done during or after calibration.

Calibration

The transmitter and one receiver are required for calibration. Make sure that the ground of the units is connected to the mains earth. Stick insulating tape over all PCB tracks that carry mains voltage to prevent them being touched by acci-

dent. It is better to screw the transmitter board to the bottom inside of the enclosure, which effectively prevents any of the mains-carrying tracks to be touched.

Begin by checking that all supply voltages at the IC sockets are as specified (do not insert the test prods into the socket terminals to prevent these losing their elasticity).

When the voltages are correct, switch off the mains and insert IC₁₀ into its socket. Temporarily interlink pin 19 and pin 1, whereupon a sine wave at an amplitude of about 9 V_{pp} should appear on an os-

cilloscope connected to pin 16. Measure the frequency of this signal with a frequency meter and adjust to 110 kHz by turning the core of Tr₂ with a plastic screwdriver. If a frequency meter is not available, use a long-wave radio receiver (preferably with digital dial). Tune the radio to 330 kHz (3rd harmonic of 110 kHz), place it close to the transmitter (in a position where the 50 Hz mains hum is not or least noticeable) and turn the core of Tr₂ for minimum noise output of the radio. Next, connect the oscilloscope across Tr₁ (at the side with the centre tap) with

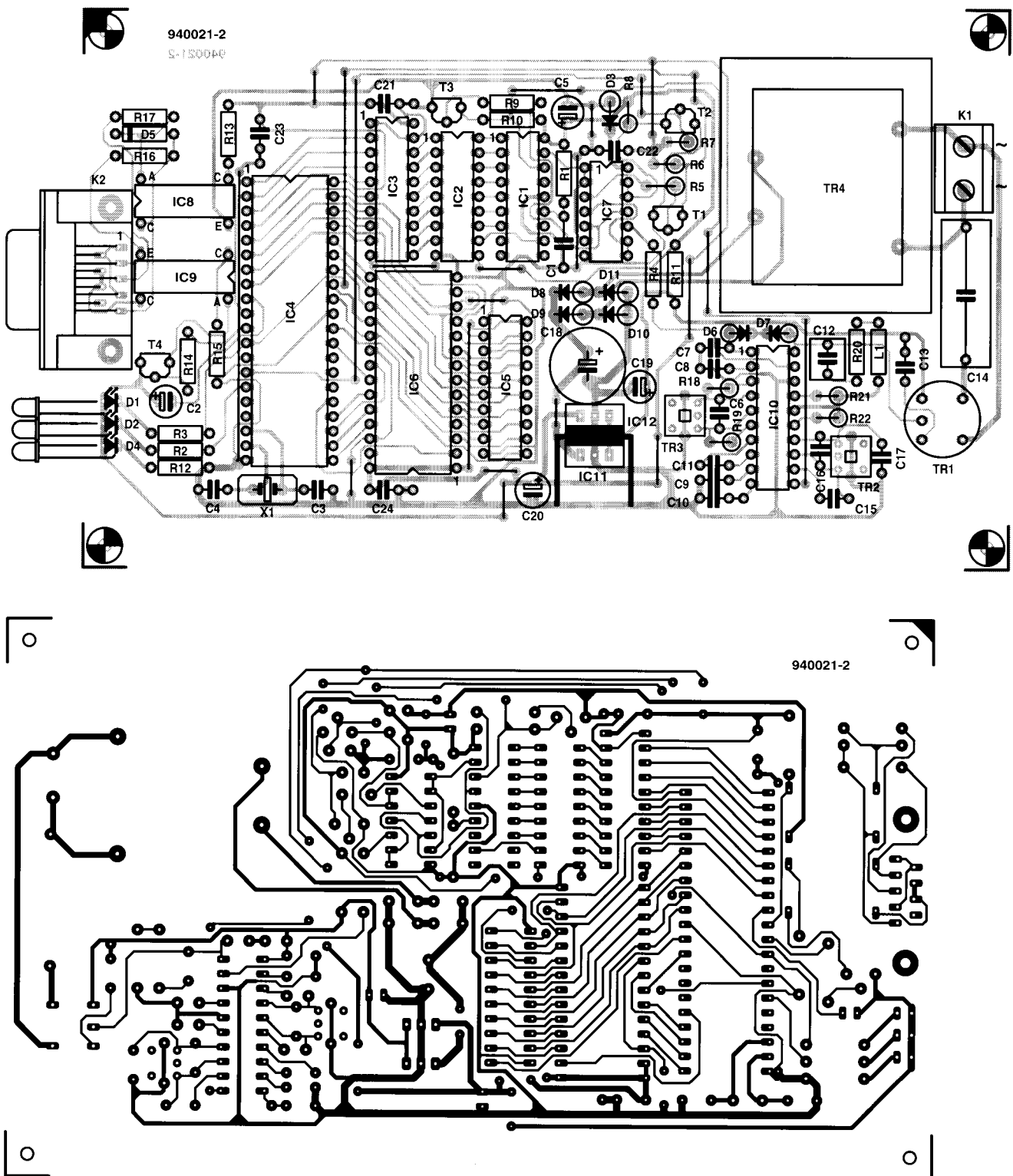


Fig. 10. Printed circuit board of the mains signalling transmitter.

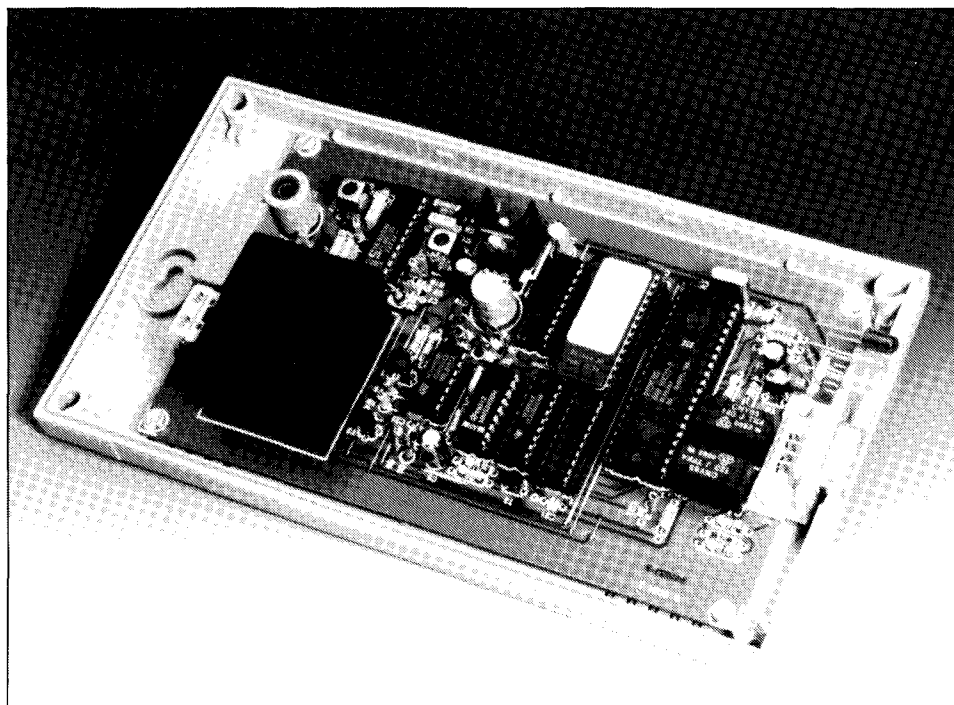


Fig. 11. Completed transmitter before enclosure is closed.

the oscilloscope ground to the +12 V terminal: disconnect the mains earth from the unit earth, since the ground of the oscilloscope is normally also connected to the mains earth. Adjust the core of Tr_1 for maximum signal level on the oscilloscope.

Then, connect the oscilloscope to pin 3 or pin 6 of IC_{10} , where a square wave at an amplitude of about 0.5 V and a d.c. offset of around 4.5 V should be available.

Next, connect the oscilloscope to pin 4 or pin 5, where a sine-wave-like signal with a sort of cross-over distortion should be present. Adjust the core of Tr_3 so that the distortion peaks are symmetrical around the cross-over points. It

will probably not be possible to obtain the same picture at pin 4 as at pin 5, but try to make them as identical as feasible.

Disconnect the link between pin 1 and pin 19 and insert the remaining ICs into their sockets and close the case.

In the receiver, take all ICs from their sockets and check the supply voltages. When these are all correct, insert IC_2 into its socket and carry out exactly the same procedure as just described for IC_{10} in the transmitter.

Insert the other ICs into their sockets.

With the use of jump leads, set the desired address on K_1 : the numbering is binary – no jumper at K_1 gives address 0 and seven jump leads give address 127.

For instance, address 1 (decimal) requires a jump lead on K_1 at the side of pin 1 of IC_5 (call this connection 1); address 100 (decimal), i.e., binary 1100100, needs jumpers on connections 3, 6 and 7. Mark the address on the outside of the case for future reference. Close the case.

Taking into use

Insert the receiver into a mains outlet and connect a mains-operated apparatus to it. At this stage, it is advisable to keep the receiver in sight.

Insert the transmitter into a different mains outlet and connect it to the computer via a serial cable of which all wires are linked 1:1, that is, **not** with the send and receive lines crossed as in a standard serial cable.

Start the program on the computer with the aid of diskette Ref. 1913 (see Parts List). The computer monitor shows an operating panel on which with the mouse or the keyboard (Alt plus underlined character) a COM port may be selected. It is also possible for a relay number to be keyed in, whereupon the software can switch over the relay. The remainder of the procedure is shown on the monitor.

It is also possible to send instructions manually to the transmitter with the aid of a communication program such as Telemate, Unicom or Procomm. The transmitter recognizes the following:

R(52_{hex})—reset transmitter (the program in the transmitter starts from the beginning).

C(43_{hex})—clear status transmitter (only status bits are reset).

T(54_{hex})—switch over the receiver: after the T, the address (0–127) of the relevant receiver must be sent as a byte.

S(53_{hex})—demand status transmitter: in this case, the transmitter sends back a byte containing the following data:

bit 0 – receiver status (0 = relay not actuated; 1 = relay energized). This is valid only if reception was correct.

bits 1–3—not used.

bit 4 – syntax error: the command sent by the computer is not recognized.

bit 5 – time out of 20 s: the bit becomes '1' if during this time no answer from the receiver has come in.

bit 6 – busy write: this is high during the period when the transmitter is waiting for an answer from the receiver.

bit 7 – busy read: this high during the period when the transmitter is waiting for an answer from the receiver.

It is, of course, possible for an individual program that uses these commands to be written in, say, Pascal or BASIC.

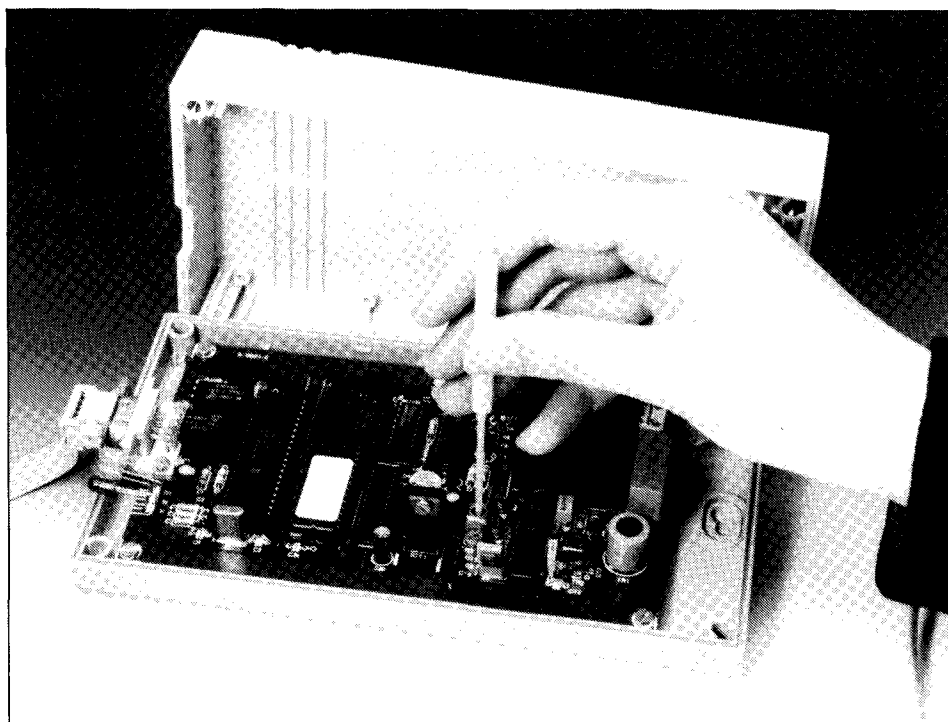


Fig. 12. Take care during the calibration: there is always the risk that open mains voltage is present somewhere on the board.

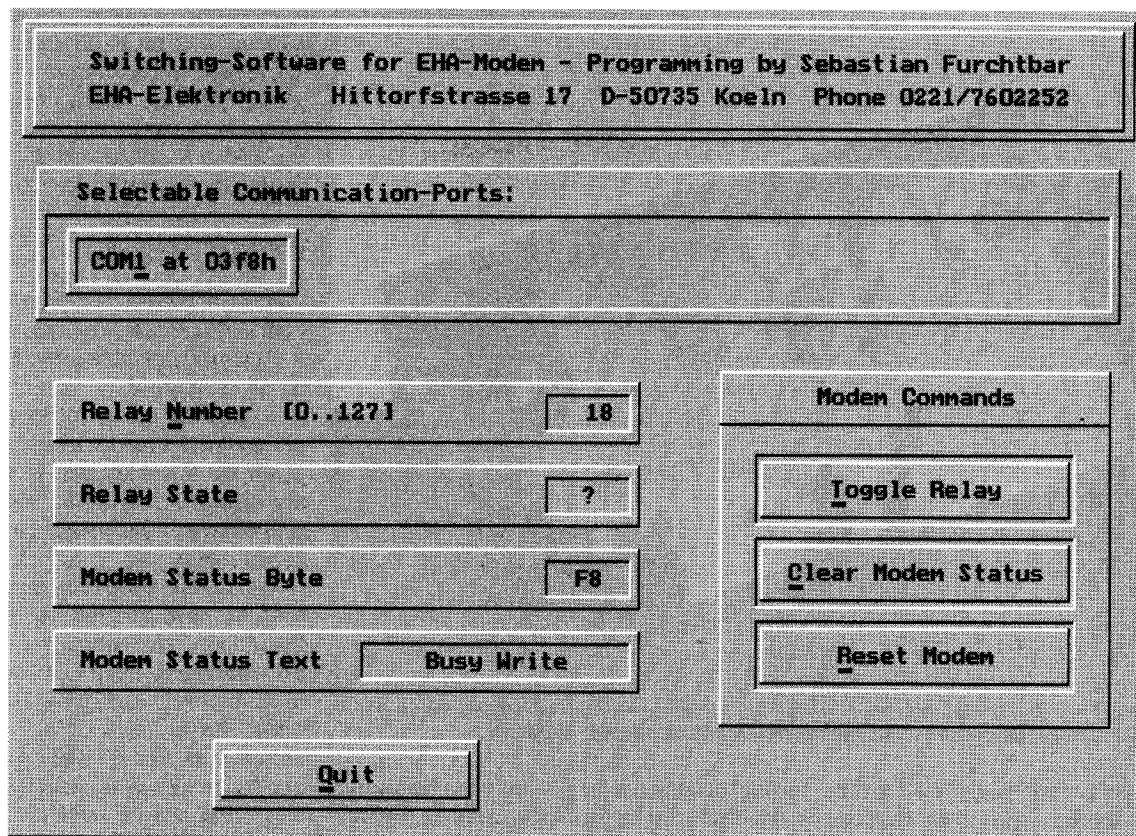


Fig. 13. Control program as seen on the computer monitor.

Parts list

Resistors:

R₁ = 180 kΩ
 R₂, R₃, R₆, R₁₂, R₁₆ = 2.2 kΩ
 R₄ = 3.9 kΩ
 R₅, R₇, R₈, R₁₀, R₁₄ = 10 kΩ
 R₉, R₁₈, R₁₉ = 5.6 kΩ
 R₁₁ = 180 Ω
 R₁₃ = 4.7 kΩ
 R₁₅ = 390 Ω
 R₁₇ = 1 kΩ
 R₂₀ = 47 Ω
 R₂₁, R₂₂ = 10 Ω

Capacitors:

C₁ = 220 pF, polystyrene
 C₂, C₅, C₁₉, C₂₀ = 10 μF, 16 V, radial
 C₃, C₄ = 33 pF
 C₆, C₁₆ = 2.2 nF*, pitch 5 mm
 C₇, C₉, C₁₇, C₂₁-C₂₄ = 100 nF*
 C₈ = 10 nF
 C₁₀, C₁₁ = 4.7 nF
 C₁₂ = 470 nF
 C₁₃ = 6.8 nF*
 C₁₄ = 470 nF, 630 V
 C₁₅ = 12 pF
 C₁₈ = 220 μF, 35 V, radial
 * = polypropylene (MKT)

Inductors:

L₁ = 390 μH

Semiconductors:

D₁ = LED, 5 mm, yellow
 D₂ = LED, 5 mm, green
 D₃ = zener, 9.1 V, 1 W
 D₄ = LED, 5 mm, red
 D₅ = 1N4148

D₆, D₇ = BZT03/C15

D₈-D₁₁ = 1N4001

T₁, T₃ = BC547

T₂ = BS170

T₄ = BC557

Integrated circuits:

IC₁ = MM53200N (National Semiconductor)

IC₂ = ULN2803

IC₃ = 74HCT541

IC₄ = 80C31

IC₅ = 74HCT573

IC₆ = EPROM Ref. 6371 (see p.70)

IC₇ = 4093

IC₈, IC₉ = CNY65

IC₁₀ = NE5050N (Philips/Signetics)

IC₁₁ = 7812

IC₁₂ = 7805

Miscellaneous:

K₁ = 2-way terminal block, pitch 7.5 mm

K₂ = 9-pole male D connector, right-angled for PCB mounting

X₁ = crystal, 12 MHz

Tr₁ = transformer T1001

(Toko No. 707VXT1002N)

Tr₂, Tr₃ = transformer 4201

(Toko No. LPCS4201 or LMCS4201) or 4100, 4101, 4102, 4200 or 4202 (also Toko)

Tr₄ = mains transformer, 15 V, 3 VA e.g., Velleman 1150038M (Maplin)

1 off heatsink 27 K W⁻¹ (Fisher Type FK228/SA from Dau, telephone (0243) 553 031)

1 off enclosure 200×112×51 mm (7⁷/₈×4⁷/₁₆×2 in), e.g., Bopla Type EG2050L - in UK represented by Phoenix Mecano Ltd, telephone (0296) 398 853

1 off PCB Ref. 940021-2 (see page 70)

1 off diskette Ref. 1913 (see page 70)

*Further information on the general aspects of mains signalling may be obtained from the BEAMA Interactive and Mains Systems Association, Leicester House, 8 Leicester Street, London WC2H 7BN. Telephone 071 437 0678. Fax 071 437 4901.

In general, for domestic applications, the level of the signal applied across the mains wiring must not exceed 116 dB μV (631 mV). Measured across the line or neutral terminal and ground, the level must not exceed 316 mV (110 dB μV). The specified impedance must be 50 Ω

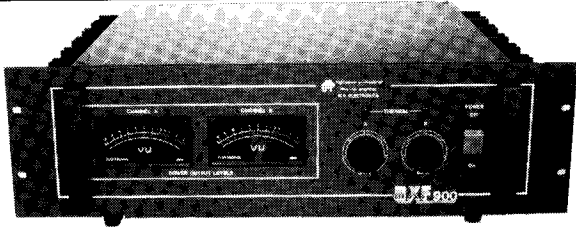
Third harmonic spurious radiations must not exceed 57 dB μV (0.7 mV).

EN 50 065-1 specifies a frequency range of 95-125 kHz.

In practice, these requirements mean that only small energy levels may be applied across the mains wiring. This in turn means that the receiver must be fairly sensitive and that spurious signals and the 50 Hz mains hum must be suppressed adequately. Moreover, as extra precautions, switching instructions must be sent several times, while at the receiver, received codes are compared several times

POWER AMPLIFIER MODULES-TURNABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

★ PRICES INCLUDE V.A.T. ★ PROMPT DELIVERIES ★ FRIENDLY SERVICE ★ LARGE (A4) S.A.E., 60p STAMPED FOR CATALOGUE ★

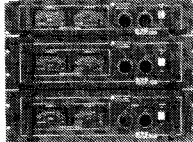
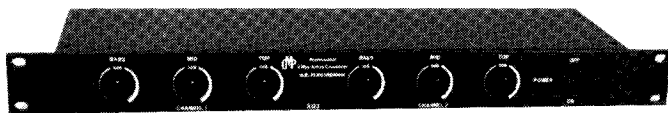
OMP MOS-FET POWER AMPLIFIERS
HIGH POWER. TWO CHANNEL 19 INCH RACK**THOUSANDS PURCHASED BY PROFESSIONAL USERS****THE RENOWNED MXF SERIES OF POWER AMPLIFIERS**
FOUR MODELS:- MXF200 (100W + 100W) MXF400 (200W + 200W)
MXF600 (300W + 300W) MXF900 (450W + 450W)
ALL POWER RATINGS R.M.S. INTO 4 OHMS, BOTH CHANNELS DRIVEN

FEATURES: ★ Independent power supplies with two toroidal transformers ★ Twin L.E.D. Vu meters ★ Level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 & MXF900 fan cooled with D.C. loudspeaker and thermal protection.

USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.

SIZES:- MXF200 W19"xH3 1/2" (2U)x11"
MXF400 W19"xH5 1/4" (3U)x12"
MXF600 W19"xH5 1/4" (3U)x13"
MXF900 W19"xH5 1/4" (3U)x14 3/4"

PRICES:- MXF200 £175.00 MXF400 £233.85
MXF600 £329.00 MXF900 £449.15
SPECIALIST CARRIER DEL. £12.50 EACH

**OMP XO3 STEREO 3-WAY ACTIVE CROSS-OVER**

Advanced 3-Way Stereo Active Cross-Over, housed in a 19" x 1U case. Each channel has three level controls: bass, mid & top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 250/500/800Hz, Mid-Top 1.8/3.5KHz, all at 24dB per octave. Bass invert switches on each bass channel. Nominal 775mV input/output. Fully compatible with OMP rack amplifier and modules.

Price £117.44 + £5.00 P&P

STEREO DISCO MIXER SDJ3400SE ★ ECHO & SOUND EFFECTS ★

STEREO DISCO MIXER with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. **MANY OUTSTANDING FEATURES:-** including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor, 8 Sound Effects. Useful combination of the following inputs:- 3 turntables (mag), 3 mics, 5 Line for CD, Tape, Video etc.



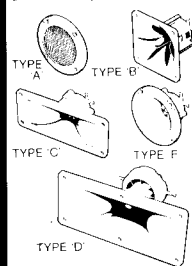
Price £144.99 + £5.00 P&P

SIZE: 482 x 240 x 120mm

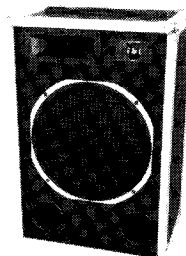
PIEZO ELECTRIC TWEETERS - MOTOROLA

Join the Piezo revolution! The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if two are put in series. **FREE EXPLANATORY LEAFLETS ARE SUPPLIED WITH EACH TWEETER.**

TYPE 'A' (KSN1036A) 3" round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi speakers. Price £4.90 + 50p P&P.
TYPE 'B' (KSN1005A) 3 1/2" super horn for general purpose speakers, disco and P.A. systems etc. Price £5.99 + 50p P&P.
TYPE 'C' (KSN1016A) 2" x 5" wide dispersion horn for quality Hi-Fi systems and quality discos etc. Price £6.99 + 50p P&P.
TYPE 'D' (KSN1025A) 2" x 6" wide dispersion horn. Upper frequency response retained extending down to mid-range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. Price £9.99 + 50p P&P.
TYPE 'E' (KSN1038A) 3 3/4" horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. Price £5.99 + 50p P&P.
LEVEL CONTROL Combines, on a recessed mounting plate, level control and cabinet input jack socket. 85x85mm. Price £4.10 + 50p P&P.

**IBI FLIGHT CASED LOUDSPEAKERS**

A new range of quality loudspeakers, designed to take advantage of the latest speaker technology and enclosure designs. Both models utilize studio quality 12" cast aluminium loudspeakers with factory fitted grilles, wide dispersion constant directivity horns, extruded aluminium corner protection and steel ball corners, complemented with heavy duty black covering. The enclosures are fitted as standard with top hats for optional loudspeaker stands.

**POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET**
FREQUENCY RESPONSE FULL RANGE 45Hz - 20KHz

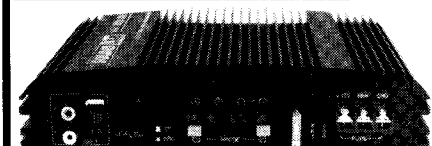
ibiFC 12-100WATTS (100dB) PRICE £159.00 PER PAIR

ibiFC 12-200WATTS (100dB) PRICE £175.00 PER PAIR

SPECIALIST CARRIER DEL. £12.50 PER PAIR

OPTIONAL STANDS PRICE PER PAIR £49.00

Delivery £6.00 per pair

IN-CAR STEREO BOOSTER AMPS

PRICES: 150W £49.99 250W £99.99
400W £109.95 P&P £2.00 EACH

THREE SUPERB HIGH POWER CAR STEREO BOOSTER AMPLIFIERS

150 WATTS (75 - 75) Stereo, 150W Bridged Mono
250 WATTS (125 + 125) Stereo, 250W Bridged Mono
400 WATTS (200 + 200) Stereo, 400W Bridged Mono
ALL POWERS INTO 4 OHMS

Features: ★ Stereo, bridged mono ★ Choice of high & low level inputs ★ L & R level controls ★ Remote on-off ★ Speaker & thermal protection.

OMP MOS-FET POWER AMPLIFIER MODULES

SUPPLIED READY BUILT AND TESTED.

These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

OMP/MF 100 Mos-Fet Output power 110 watts
R.M.S. into 4 ohms, frequency response 1Hz - 100KHz
-3dB, Damping Factor >300, Slew Rate 45V/uS,
T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R.
-110 dB. Size 300 x 123 x 60mm.
PRICE £40.85 + £3.50 P&P



OMP/MF 200 Mos-Fet Output power 200 watts
R.M.S. into 4 ohms, frequency response 1Hz - 100KHz
-3dB, Damping Factor >300, Slew Rate 50V/uS,
T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R.
-110 dB. Size 300 x 155 x 100mm.
PRICE £64.35 + £4.00 P&P



OMP/MF 300 Mos-Fet Output power 300 watts
R.M.S. into 4 ohms, frequency response 1Hz - 100KHz
-3dB, Damping Factor >300, Slew Rate 60V/uS,
T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R.
-110 dB. Size 330 x 175 x 100mm.
PRICE £81.75 + £5.00 P&P



OMP/MF 450 Mos-Fet Output power 450 watts
R.M.S. into 4 ohms, frequency response 1Hz - 100KHz
-3dB, Damping Factor >300, Slew Rate 75V/uS,
T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R.
-110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2
Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE £132.85 + £5.00 P&P



OMP/MF 1000 Mos-Fet Output power 1000 watts
R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms,
frequency response 1Hz - 100KHz -3dB, Damping
Factor >300, Slew Rate 75V/uS, T.H.D. typical
0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan
Cooled, D.C. Loudspeaker Protection, 2 Second
Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE £259.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS:
STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz.
PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS
775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

LOUDSPEAKERS

LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE (A4) S.A.E. (60p STAMPED) FOR COMPLETE LIST.

McKenzie and Fane Loudspeakers are also available.

EMINENCE- INSTRUMENTS, P.A., DISCO, ETC**ALL EMINENCE UNITS 8 OHMS IMPEDANCE**

8" 100 WATT R.M.S. ME8-100 GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID, DISCO.
RES. FREQ. 72Hz, FREQ. RESP. TO 4KHz, SENS 97dB. **PRICE £32.71 + £2.00 P&P**
10" 100 WATT R.M.S. ME10-100 GUITAR, VOCAL, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 71Hz, FREQ. RESP. TO 7KHz, SENS 97dB. **PRICE £33.74 + £2.50 P&P**
10" 200 WATT R.M.S. ME10-200 GUITAR, KEYB'D, DISCO, VOCAL, EXCELLENT HIGH POWER MID.
RES. FREQ. 65Hz, FREQ. RESP. TO 3.5KHz, SENS 99dB. **PRICE £43.47 + £2.50 P&P**
12" 100 WATT R.M.S. ME12-100LE GEN. PURPOSE, LEAD GUITAR, DISCO, STAGE MONITOR.
RES. FREQ. 49Hz, FREQ. RESP. TO 6KHz, SENS 100dB. **PRICE £35.64 + £3.50 P&P**
12" 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE
MONITOR. RES. FREQ. 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. **PRICE £36.67 + £3.50 P&P**
12" 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID.
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. **PRICE £46.71 + £3.50 P&P**
12" 300 WATT R.M.S. ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC.
RES. FREQ. 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB. **PRICE £70.19 + £3.50 P&P**
15" 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR.
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB. **PRICE £50.72 + £4.00 P&P**
15" 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR.
RES. FREQ. 39Hz, FREQ. RESP. TO 3KHz, SENS 103dB. **PRICE £73.34 + £4.00 P&P**

EARBENDERS- HI-FI, STUDIO, IN-CAR, ETC

ALL EARBENDER UNITS 8 OHMS (Except EB8-50 & EB10-50 which are dual impedance tapped @ 4 & 8 ohm)
BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND
8" 50WATT EB8-50 DUAL IMPEDANCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR. **PRICE £8.90 + £2.00 P&P**
RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz SENS 97dB.
10" 50WATT EB10-50 DUAL IMPEDANCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR. **PRICE £13.65 + £2.50 P&P**
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB.
10" 100WATT EB10-100 BASS, HI-FI, STUDIO. **PRICE £30.39 + £3.50 P&P**
RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB.
12" 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO. **PRICE £42.12 + £3.50 P&P**
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB.
FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND
5 1/4" 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC. **PRICE £9.99 + £1.50 P&P**
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB.
6 1/2" 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC. **PRICE £10.99 + 1.50 P&P**
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB.
8" 60WATT EB8-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC. **PRICE £12.99 + £1.50 P&P**
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB.
10" 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC. **PRICE £16.49 + £2.00 P&P**
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB.

TRANSMITTER HOBBY KITS

PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS

3W TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 36 x 123mm, SUPPLY 12V @ 0.5AMP.
PRICE £14.85 + £1.00 P&P

FM MICRO TRANSMITTER 100-108MHz, VARICAP TUNED, COMPLETE WITH VERY SENS FET MIC, RANGE 100-300m, SIZE 56 x 48mm, SUPPLY 9V BATTERY.
PRICE £9.80 + £1.00 P&P



PHOTO: 3W FM TRANSMITTER

B.K. ELECTRONICS

UNITS 1 & 5 COMET WAY, SOUTHEM-ON-SEA,
ESSEX, SS2 6TR.

Tel.: 0702 - 527572 Fax.: 0702 - 420243

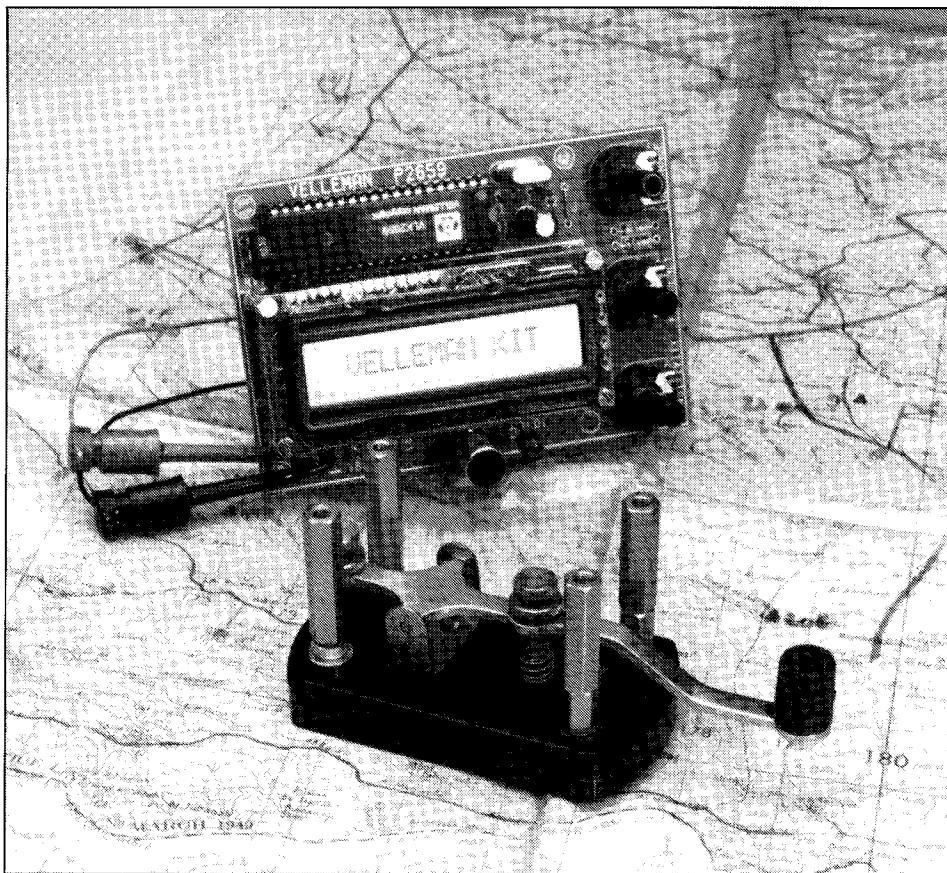


POSTAL CHARGES PER ORDER £1.00 MINIMUM. OFFICIAL ORDERS FROM SCHOOLS, COLLEGES, GOVT. BODIES, PLCs ETC. PRICES INCLUDE V.A.T. SALES COUNTER, VISA AND ACCESS ACCEPTED BY POST, PHONE OR FAX.



MORSE DECODER

Some of you may call them hopelessly old-fashioned, but they can still be heard at many frequencies when tuning across the short-wave bands, those unsurpassed long and short tones used to convey messages by radio. Telegraphy, or morse, still exists in the face of the tremendous strides that have been made in modern communication technology. The morse decoder described in this article is available as a kit from Velleman distributors, and enables those cryptic tones from your communication receiver to be deciphered, and turned into text on a liquid crystal display.



Design: © '94 Velleman N.V., Belgium.

MORSE or telegraphy code is a communication method developed at a time when it was impossible to convey speech reliably over large distances using radio links. The morse transmitter is the simplest type of transmitter in existence because basically it is switched on and off by a morse key. Using a relatively simple protocol, the 26 letters in the alphabet, numbers 0 through 9, and a number of punctuation signs, are encoded into a series of short and long tones, which are often called 'dots' (short tones) and 'dashes' (long tones).

Morse transmissions can be re-

ceived in the short-wave and long-wave bands using a communication receiver fitted with a narrow IF (intermediate frequency) filter and a beat frequency oscillator (BFO). To the uninitiated, morse code is just a series of meaningless tones. Experienced morse operators (or 'telegraphists'), however, are capable of copying messages from very weak signals buried under a lot of interference. Meanwhile, they will chat with you, write down the message and smoke a cigarette. This proficiency level and skill is impossible to achieve without training and years of experience. Not surprisingly, many amateurs

prefer the automated solution, for which the present morse decoder is the perfect companion.

The circuit

The circuit diagram of the morse decoder is given in **Fig. 1**. Broadly speaking, the schematic may be divided into three parts. The circuit around IC₂ turns the morse signal into a digital pulse train. The digital circuit around microcontroller IC₁ turns the digital pulses into text which can be read on a liquid crystal display (LCD). The display used is capable of showing up to 16 characters on one line.

The third section of the circuit is the power supply, which consists of a mains transformer (2×8 V at 150 mA), a double-phase rectifier, and an integrated 5-V regulator. Obviously, the transformer may be replaced by a suitable mains adaptor with an output voltage of between 9 and 12 V.

The input stage of the morse decoder is simple, but effective. The analogue signal picked up by the electret microphone is applied to the input of IC₂ via a coupling capacitor. The XR2211 in position IC₂ is an integrated FSK (frequency-shift keying) demodulator/tone decoder from Exar. As shown by the internal block diagram in **Fig. 2**, this IC contains all components needed to use it as a tone decoder.

The design of a tone decoder should take into account the wide frequency spread of the morse tones. The actual frequency of the morse tones produced by the communication receiver is never fixed because it depends on the exact tuning and, in some cases, the BFO (beat frequency oscillator) setting. Hence, the frequency to which the tone decoder responds is made adjustable. This adjustment is carried out with potentiometers RV₃ (frequency) and RV₄ (lock range). Components C₄, R₁₁ and RV₃ turn the VCO (voltage controlled oscillator) contained in the XR2211 into a variable frequency oscillator. The detector, another sub-circuit of the XR2211, compares the frequency of the oscillator output signal with that of the morse tones picked up by the microphone. Since the frequency of the morse tones can vary considerably, a certain capture range is provided, the span of which is determined by R₈ and RV₄. With the component values shown, the decoder is capable of locking on to frequencies between 77 Hz and 240 Hz with RV₃ set to minimum. This capture range is changed to 550 Hz to 1720 Hz with RV₃ set to

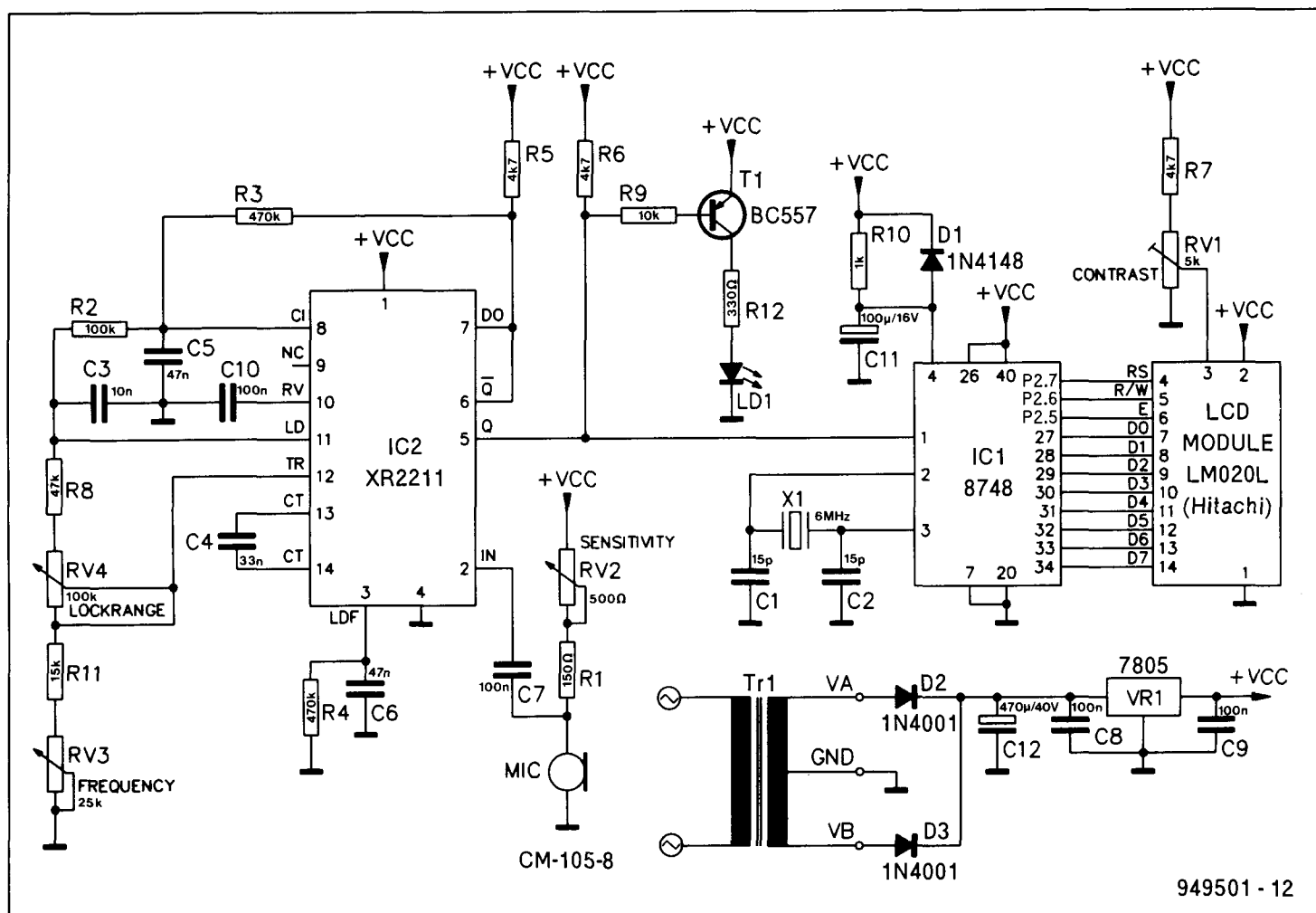


Fig. 1. Circuit diagram of the morse decoder, which is available as a kit through Velleman distributors.

maximum. In both cases, the lock range pot, RV₄, is set to maximum. The adjustment of the two potentiometers can be optimized as soon as a morse transmission is picked up, and the first characters start to appear on the LCD. The two adjustments serve to minimize the decoder's susceptibility to noise, which is unfortunately inherent to radio signals.

The sensitivity of the decoder is adjusted with RV₂. It is recommended to use the lowest possible sensitivity which allows a good degree of acoustic coupling to be achieved. As with the previously mentioned frequency and lock range adjustments, this helps to keep the distorting effect of noise sources beleaguering the morse signals to a minimum. If desired, R₁, RV₂ and the microphone may be omitted, and replaced by a simple input stage with a resistor of 47 kΩ to ground. This allows the decoder to be connected directly to the receiver's line output.

The correct operation of the tone decoder may be verified by looking at LED LD₁. If the LED lights in the rhythm of the morse tones, you may safely assume that the tuning and other adjustments are correct or about correct.

Apart from the LED driver, T₁, the

morse signals are also applied to the input of microcontroller IC₁. The controller runs at a clock of 6 MHz, and turns the serial datastream at its input into corresponding parallel codes which can be recognized by the LCD. Preset RV₁ serves to set the LCD contrast for the best legibility/brightness trade-off, which will take you only half a minute or so to find.

The microcontroller used here is a Type 8748 from Intel's MCS48 family. The 8748 has on-board RAM and ROM. The decoder software is located in ROM, and has been developed by Velleman N.V.

Components R₁₀ and C₁₁ supply the microcontroller with a reset signal at power-on. Diode D₁ ensures that capacitor C₁₁ is discharged rapidly when the circuit is switched off. Capacitor C₁₁ has a value of 10 μF in the kit supplied by Velleman. Based on practical experience, we recommend changing this into 100 μF to ensure a more reliable reset.

Construction

Assembling the decoder is easy using the components and the printed circuit board contained in the kit. The

track layout and component mounting plan of the printed circuit board designed for the morse decoder are shown in Fig. 3. Construction is straightforward, and no problems are expected to arise if you work carefully. The LC display module is fitted on to

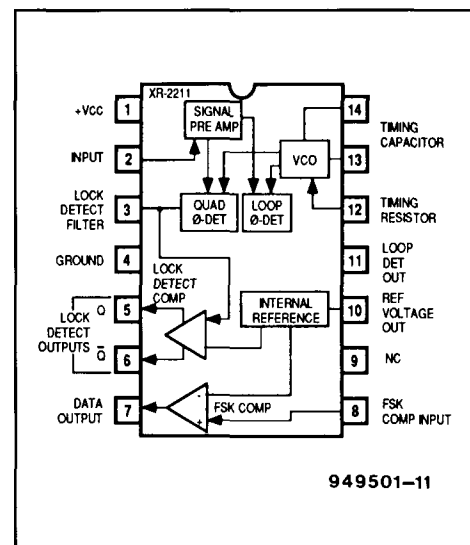


Fig. 2. Internal organization of the XR2211 FSK demodulator/tone decoder (courtesy Exar).

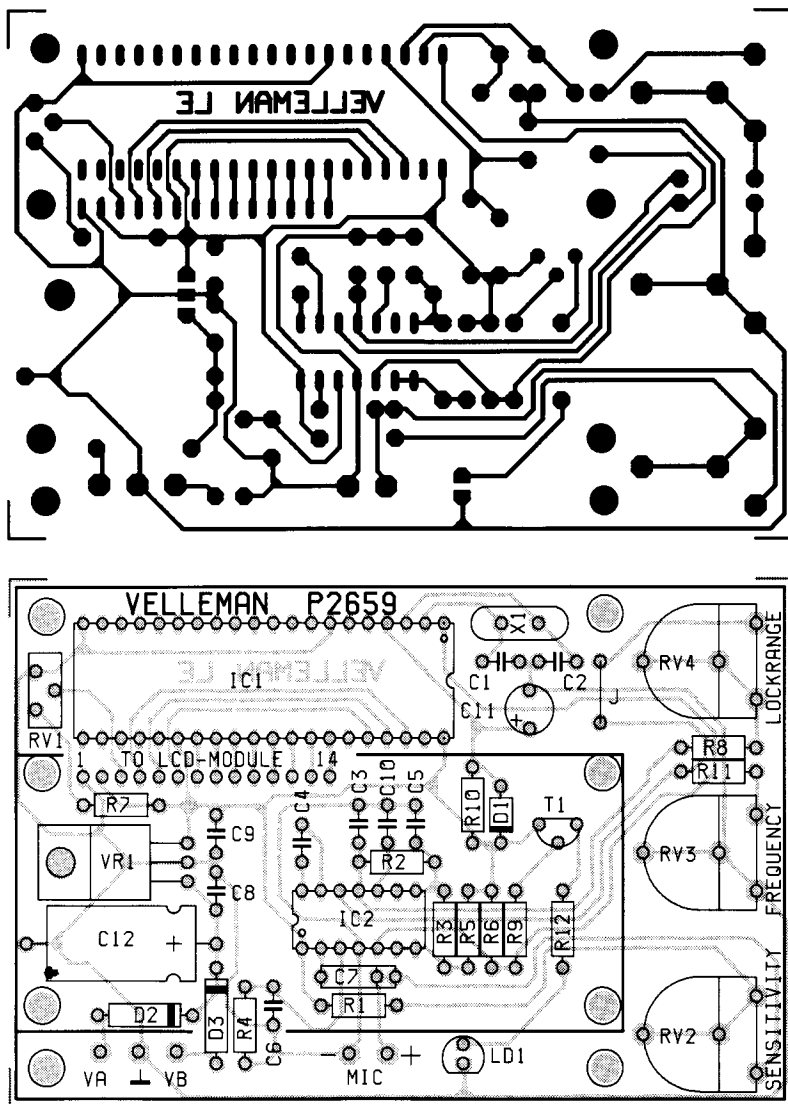


Fig. 3. Track layout (reflected) and component mounting plan of the single-sided PCB included in the kit.

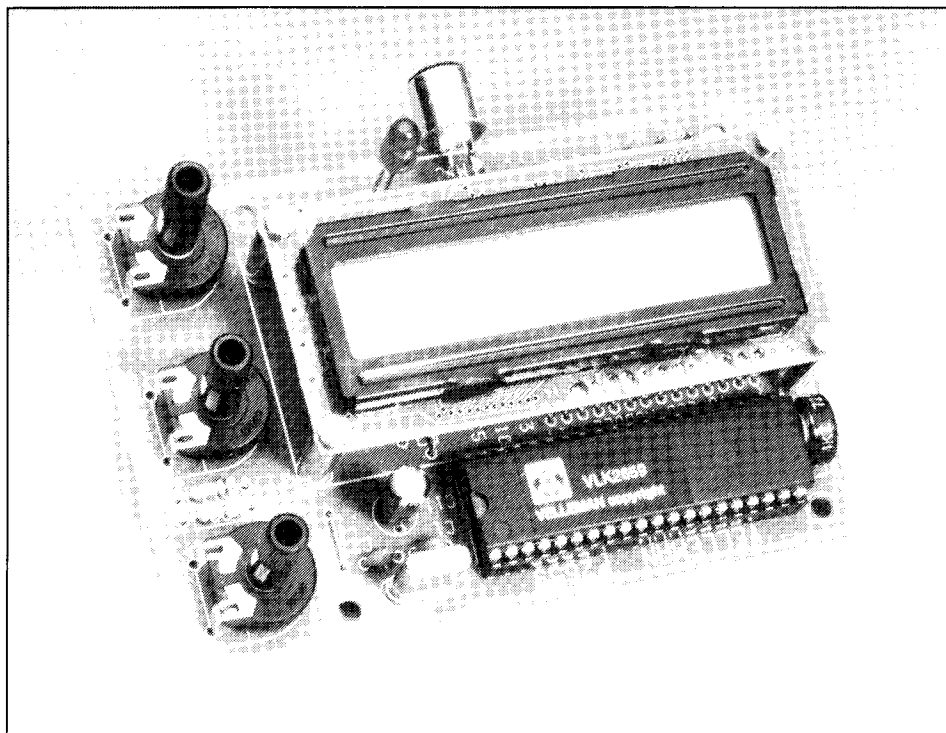


Fig. 4. Completed morse decoder. If desired, the unit may be built into a suitable case.

COMPONENTS LIST

Resistors:

R1 = 150Ω
 R2 = 100kΩ
 R3, R4 = 470kΩ
 R5, R6, R7 = 4kΩ
 R8 = 47kΩ
 R9 = 10kΩ
 R10 = 1kΩ
 R11 = 15kΩ
 R12 = 330Ω
 RV1 = 5kΩ preset
 RV2 = 500Ω preset
 RV3 = 25kΩ preset
 RV4 = 100kΩ preset

Capacitors:

C1, C2 = 15pF
 C3 = 10nF
 C4 = 33nF
 C5, C6 = 47nF
 C7, C8, C9, C10 = 100nF
 C11 = 100μF 16V
 C12 = 470μF 16V

Semiconductors:

IC1 = programmed 8748 (supplied by Velleman: order no. VK2659)
 IC2 = XR2211
 VR1 = 7805
 T1 = BC557
 D1 = 1N4148
 D2, D3 = 1N4001
 LD1 = LED red

Miscellaneous:

Mic = M300 or CM-105-8.
 X1 = quartz crystal 6MHz
 Tr1 = 2x9V/4.2VA (e.g. Velleman 2090050M).
 One 1-line, 16-character LCD module, HLM1615 or Hitachi LM020L.

Kits for the morse decoder are available from

Maplin Electronics, P.O. Box 3,
 Rayleigh, Essex SS6 2BR. Tel. (0702) 554161, fax (0702) 553935.

Circuit Distribution Ltd., Park Lane,
 Broxbourne, Herts EN10 7NQ. Tel.: (0992) 444111, fax (0992) 464457.

the board with the aid of four PCB pillars. This is done after all other parts have been mounted on the board. The display is connected to the board via short lengths of flexible wire. Insert the spindles into the three presets on the board, and connect the microphone via a short length of screened wire, so that it can be mounted close to the receiver's loudspeaker.

Apply power, and check that the dis-

Morse, a simple code

The morse or telegraphy code was developed to convey messages over radio and telegraph wire links with a very limited bandwidth. Apart from the complete alphabet, the code set also includes numbers and a couple of punctuation signs. The complete morse alphabet was developed by Samuel Morse, who lived from 1791 to 1872. This American is also the inventor of the writing telegraph (1837). All morse codes are a combination of two elementary characters: a dot (.) and a dash (—). The dot has a length of one time unit, the dash, a length of three units. The length of the pause between a dot and a dash, but also between a dot and a dot, and a dash and a dash, is fixed at one unit. The length of the pause between letters, numbers or signs equals three units. Similarly, the pause between words or number groups equals six (or seven) time units. The actual length (say, in ms) of the time unit is not defined, and is merely a relative indicator of the transmission speed. In most cases, however, a time unit is simply equal to a dot.

Letters

A	• —
B	— • • •
C	— • — •
D	— • •
E	•
F	• — • •
G	— • —
H	• • • •
I	• •
J	• — — —
K	— • —
L	• — • •
M	— —
N	— •
O	— — —
P	• — — •
Q	— — • —
R	• — •
S	• • •
T	—
U	• • —
V	• • • —
W	• — —
X	— • — —
Y	• • — —
Z	— — • •

Numbers

1	• — — — —
2	• • — — —
3	• • • — —
4	• • • • —
5	• • • • •
6	— • • • •
7	— — • • •
8	— — — • •
9	— — — — •
0	— — — — —

Punctuation signs

-	— • • • •
?	• • — — • •
(	— • — — •
)	— • — — •
.	• — • — • —
,	— — — — •
"	• • • — •
'	• — — — — •
=	— • • • —
/	— • — — •
+	• — • — •
:	— — — • • •
×	— • • — —

Special codes

Warning	• — • • —
Error	• • • • • • •
Repeat	• • • •
Wait (AS)	• — • • •
Break (BK)	— • • • — • —
Copied (VE)	• • • — •
Transmission received (R)	• — •
Start of message (KA)	— • — • —
End of message (AR)	• — • — •
End of transmission (K)	— • —
End of transmission (KN)	— • — — •
Closing sign (SK)	• • • — • —
Transmitter closedown (CL)	— • — • • — •

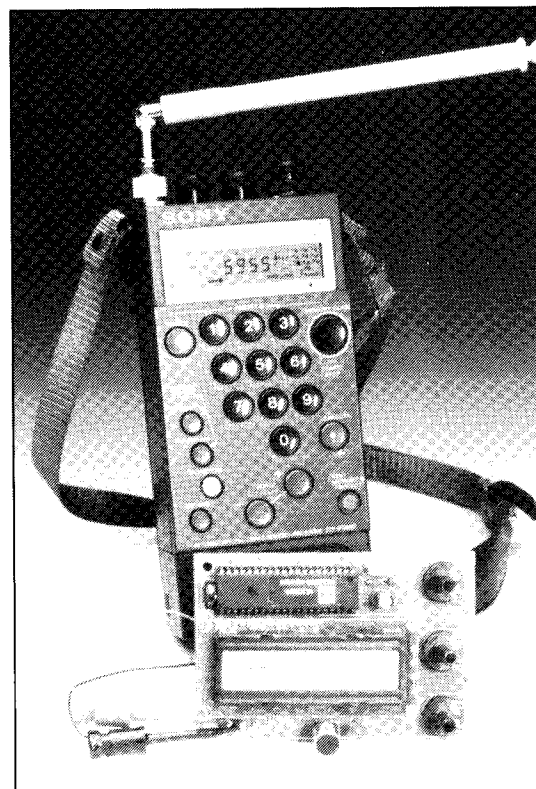


Fig. 5. The morse decoder in action. Any morse signal can be picked from the 'aether', decoded into text, and thrown on to a scrolling LC display for you to read.

time (in most cases, that will be a utility station, not a radio amateur).

Next, switch on the morse decoder. After the test message 'Velleman kit', the decoded text should scroll along horizontally across the display. Using the LED as an indicator, the best possible adjustment of the tone frequency and the lock range will soon be found. Reduce the receiver volume, or the decoder sensitivity, if the LED appears to light continuously, since that indicates that the circuit is being overdriven. If the LED is nearly always out, the microphone does not pick up enough signal, and the acoustic coupling should be examined. ■

play reads 'Velleman kit'. This indicates that the hardware is operational. Switch off again.

Adjustment

Before you can start adjusting the various controls on the morse decoder, it is necessary to tune to a strong, clear, morse transmission. In many cases, these can be picked up from Coast Guard and similar utility stations transmitting at countless frequencies

across the short-wave bands. The prototype of the kit assembled in our design laboratory was tested with the morse signals received from Scheveningen Radio (PCH20) coast guard on 4,250 kHz. Set the receiver to CW mode, or SSB using the BFO, and adjust the tuning until the morse tones sound as clear as possible. Some background noise is normal and no cause for alarm. In any case, make sure you use a good antenna, and select a station which remains on the air for some

SURVEILLANCE

PROFESSIONAL QUALITY KITS

No. 1 for Kits

Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio.

Genuine SUMA kits available only direct from Suma Designs. Beware inferior imitations!

UTX Ultra-miniature Room Transmitter

Smallest room transmitter kit in the world! Incredible 10mm x 20mm including mic. 3-12V operation. 500m range.....£16.45

MTX Micro-miniature Room Transmitter

Best-selling micro-miniature Room Transmitter
Just 17mm x 17mm including mic. 3-12V operation. 1000m range.....£13.45

STX High-performance Room Transmitter

Hi performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22mm including mic. 6-12V operation, 1500m range.....£15.45

VT500 High-power Room Transmitter

Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm. 9-12V operation. 3000m range.....£16.45

VXT Voice Activated Transmitter

Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range...£19.45

HVX400 Mains Powered Room Transmitter

Connects directly to 240V AC supply for long-term monitoring. Size 30mm x 35mm. 500m range.....£19.45

SCRX Subcarrier Scrambled Room Transmitter

Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range.....£22.95

SCLX Subcarrier Telephone Transmitter

Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range.....£23.95

SCDM Subcarrier Decoder Unit for SCRX

Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9-12V operation.....£22.95

ATR2 Micro Size Telephone Recording Interface

Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line.....£13.45

UTLX Ultra-miniature Telephone Transmitter

Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm! Connects to line (anywhere) and switches on and off with phone use. All conversation transmitted. Powered from line. 500m range.....£15.95

TLX700 Micro-miniature Telephone Transmitter

Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range.....£13.45

STLX High-performance Telephone Transmitter

High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. Size 22mm x 22mm. 1500m range.....£16.45

TX900 Signalling/Tracking Transmitter

Transmits a continuous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m. Size 25mm x 63mm. 9V operation.....£22.95

CD400 Pocket Bug Detector/Locator

LED and piezo bleeper pulse slowly, rate of pulse and pitch of tone increase as you approach signal. Gain control allows pinpointing of source. Size 45mm x 54mm. 9V operation.....£30.95

CD600 Professional Bug Detector/Locator

Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation.....£50.95

QTX180 Crystal Controlled Room Transmitter

Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRX180 kit (see catalogue). Size 20mm x 67mm. 9V operation. 1000m range.....£40.95

QLX180 Crystal Controlled Telephone Transmitter

As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range.....£40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter

As per QLX180 but draws power requirements from line. No batteries required. Size 32mm x 37mm. Range 500m.....£35.95

QRX180 Crystal Controlled FM Receiver

For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as a pre-built and aligned module ready to connect on board so no difficulty setting up. Outpt to headphones. 60mm x 75mm. 9V operation.....£60.95

A build-up service is available on all our kits if required.

UK customers please send cheques, POs or registered cash. Please add £1.50 per order for P&P. Goods despatched ASAP allowing for cheque clearance. Overseas customers send sterling bank draft and add £5.00 per order for shipment. Credit card orders welcomed on 0827 714476.

OUR LATEST CATALOGUE CONTAINING MANY MORE NEW SURVEILLANCE KITS NOW AVAILABLE. SEND TWO FIRST CLASS STAMPS OR OVERSEAS SEND TWO IRCS.

★★★ Specials ★★★

DLTX/DLRX Radio Control Switch

Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output, momentary or alternate, 8-way dii switches on both boards set your own unique security code. TX size 45mm x 45mm. RX size 35mm x 90mm. Both 9V operation. Range up to 200m.

Complete System (2 kits).....£50.95

Individual Transmitter DLTX.....£19.95

Individual Receiver DLRX.....£37.95

MBX-1 Hi-Fi Micro Broadcaster

Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your favourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle. Size 27mm x 60mm. 9V operation. 250m range.....£20.95

**SUMA
DESIGNS**

DEPT. EE

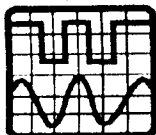
THE WORKSHOPS, 95 MAIN ROAD,
BAXTERLEY, NEAR ATHERSTONE,
WARWICKSHIRE CV9 2LE

VISITORS STRICTLY BY APPOINTMENT ONLY



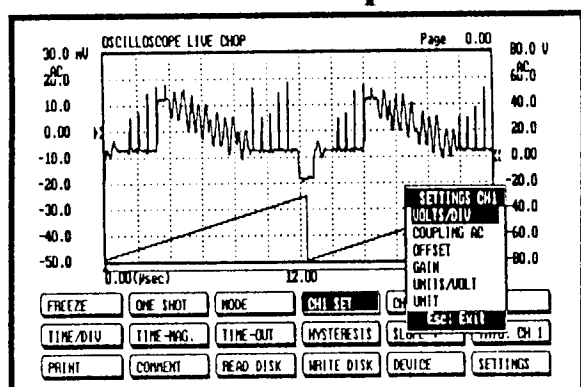
Tel: 0827 714476

Fax: 0827 714476

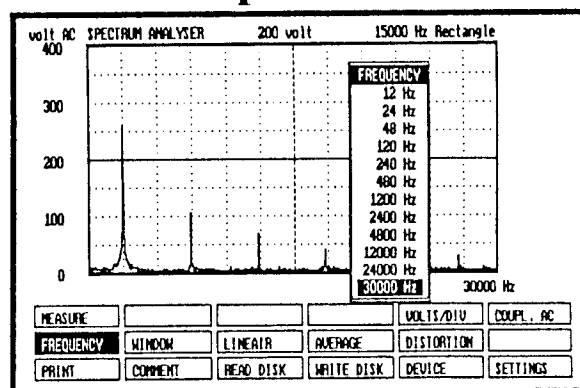


TEST and MEASURE with your COMPUTER.

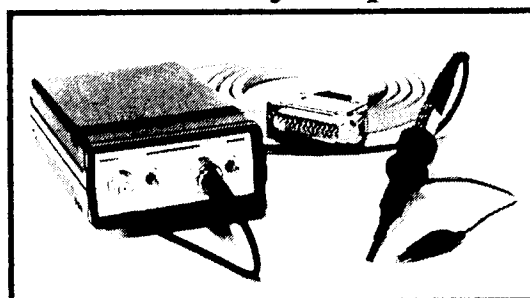
Oscilloscopes



Spectrum



Handyscope



PRINTER PORT

BUS SLOT

MULTI INSTRUMENTS

COLOUR SOFTWARE

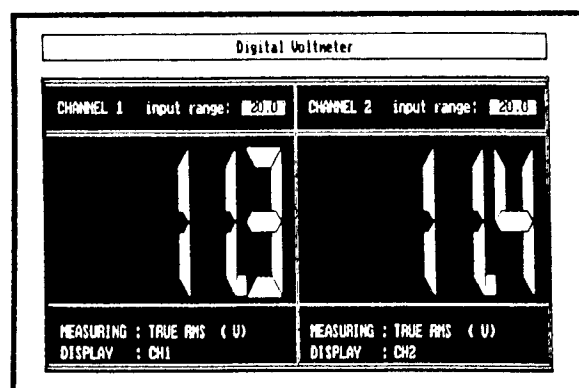
DUAL CHANNEL

BI-POLAR

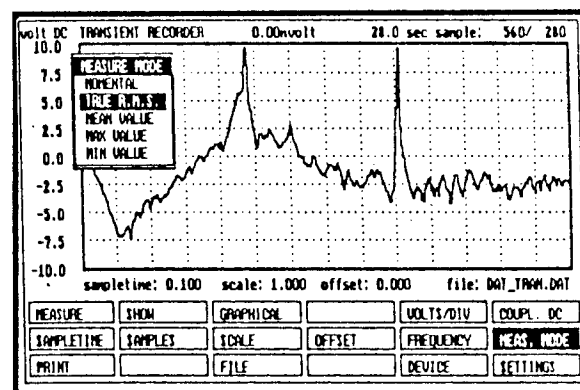
ACCURACY 0.25%

400V peak-peak

Multimeter



Transient



For more information on the HANDYSCOPE and other data acquisition instruments please contact...

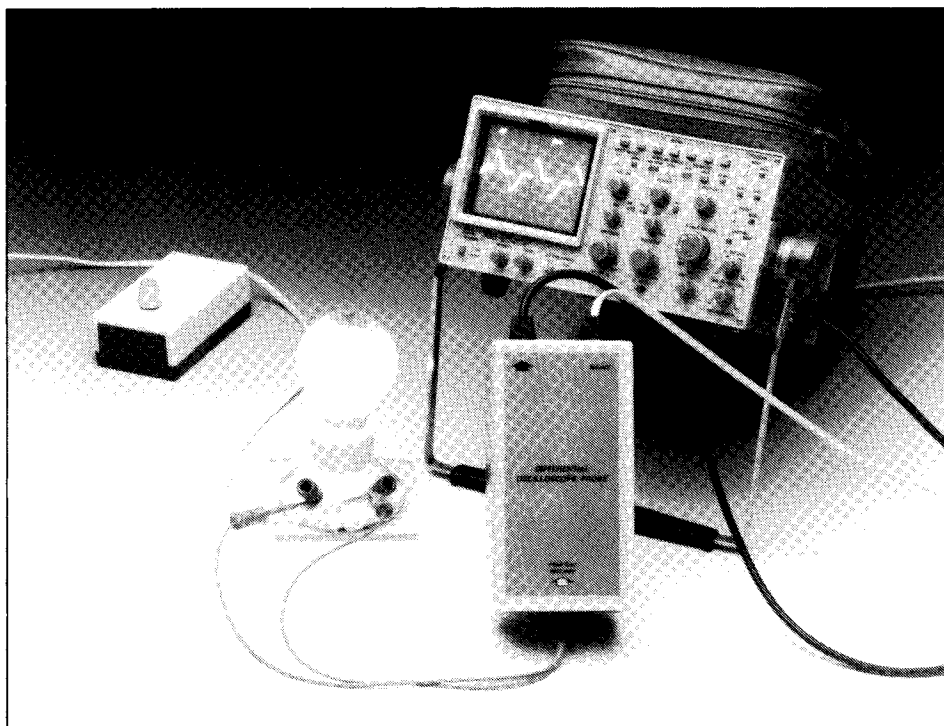
INSTRUTEK (UK)

TEL: (0480) 460028 FAX: (0480) 460340.

DIFFERENTIAL PROBE FOR OSCILLOSCOPES

Design by H. Bonekamp

The probe described overcomes several of the shortcomings of the probe supplied with many oscilloscopes. It is a 10:1/100:1 design that enables floating measurements to be carried out. Its presettable attenuation to 10 V or 100 V and its facility for floating measurements makes it also suitable for measuring high voltages.



When the resistive or capacitive load connected to many oscilloscopes is too large, serious measurement errors may occur. Moreover, the voltage range on many oscilloscopes is limited to 5 V graticules, so that the maximum voltage that can be measured is 40 V. This is, of course, improved by the supplied 10:1 probe to 400 V, but even this is inadequate for many applications. Another problem with a number of oscilloscopes is created by the external (mains) earth being permanently connected to the ground of the instrument. Since, moreover, the equipment on which measurements are carried out is often also connected to the mains earth, a potentially dangerous situation may arise when very high voltages are measured. This also means that measurements are always referred to earth: in mains-operated apparatus it is virtually impossible to measure the potential between two random points.

Differential measurements

Measurements **not** referred to earth can be made only by using a differential probe. Such a probe has two prods, each of which 'floats' with respect to earth. An accurate differential amplifier/buffer ensures that

the probe is provided with the true potential difference between the prods. Differential probes with presettable attenuator are commercially available, but tend to be fairly expensive. The present probe is considerably less so.

Since the probe must not noticeably load the equipment on test, its input resistance is high and its input capacitance low. Moreover, the input is frequency compensated to ensure that linear performance is obtained over a wide frequency range. The attenuator networks for each prod are as nearly equal as possible. Moreover, the common-mode suppression is high.

The circuit

The circuit—see **Fig. 1**—is based on special dual differential amplifier IC₁. This is a wide-band device that provides accurate processing of a differential input signal. Moreover, it attenuates common-mode signals up to very high frequencies. Basically, it consists of two separate differential amplifiers followed by a common buffer. Pins 1 and 2 respectively form the +ve and -ve inputs of one and pins 3 and 4 those of the other. The common output is available at pin 7. Feedback network R₁₀-R₁₁ fixes the amplification at ×2. The potential divider at pin 4 ensures accurate compensation of the d.c. offset (owing to the offset current, the value of R₉ is equal to that of R₁₀ and R₁₁ in parallel).

The attenuator networks are situated between IC₁ and connector K₁ (to which the test prods are connected). They consist of precision resistors R₁-R₇. Frequency compensation is provided by capacitors C₁-C₈. With values as specified, the input resistance is about 2 MΩ and the input capacitance around 2.5 pF. Moreover, the specified values ensure that the time constants in the probe are determined by the actual components rather than by parasitic effects.

Since for good common-mode suppression equality of the networks is imperative, one has a fixed 10-Ω resistor (R₄), whereas the corresponding (20-Ω) resistance in the other is variable (P₁). This arrangement makes it possible for any measurement error to be nullified.

PARAMETERS

Attenuation	100:1 or 10:1
R _{in}	2 MΩ (approx)
C _{in}	<2.5 pF (without test leads)
U _{in} (differential)	450 V peak; 450 V r.m.s.
U _{in} (common mode)	700 V peak; 500 V r.m.s.
Bandwidth	20 MHz (100:1) 15 MHz (10:1)
CMRR	80 dB (up to 100 kHz) 60 dB (up to 1 MHz) 40 dB (up to 10 MHz)
Accuracy (see text)	0.6% max (100:1)

Moreover, variable capacitors C_4 and C_8 enable equality of the networks to be achieved at high frequencies.

Although the wanted maximum attenuation factor is 100:1, the input attenuator is set to 200:1. This is to keep the differential input voltage of IC_1 within limits: the AD830 has internal limiting that comes into operation when the level of the differential signal reaches 2.3 V. As the amplification of the device is $\times 2$, the final attenuation is 100:1.

Because of the internal limiting in IC_1 , it is not possible to switch the input attenuator to 10:1 without degradation of the common-mode suppression. This is resolved by adding amplifier IC_2 . The amplification of this stage can be switched between 1 and 10, so that the attenuation can be switched between 10:1 and 100:1. So as to affect the bandwidth of IC_2 as little as possible, the input resistance, rather than the feedback resistance, is switched (by S_1) between 1 k Ω (R_{12}) and 100 Ω (R_{13} in parallel with R_{14}).

The output impedance of the probe is

50 Ω (R_{15}) to ensure good matching to RG58 coaxial cable.

The operating voltage for the probe is provided by a standard supply. The two power lines are stabilized by regulators IC_3 and IC_4 . Each rectifier diode is shunted by a capacitor to eliminate any spurious signals. Diode D_1 functions as an on/off indicator.

Note that each of the ICs is individually decoupled for r.f. by C_{17} - C_{18} and C_{19} - C_{20} respectively: this measure is necessary with fast devices.

As already stated, attenuator resistors R_1 - R_7 are close-tolerance (0.1%) types, whereas R_9 - R_{14} are precision (1%) types. This gives an overall measurement accuracy of 4.2%, which is an acceptable practical value. If maximum accuracy (0.6% in the 100:1 position and 1.6% in the 10:1 position) is required, R_9 - R_{14} must also be 0.1% types. If 0.1% resistors can not be obtained, R_1 - R_7 may be 1% types, but the value of R_4 and P_1 must then be increased to 100 Ω and 200 Ω respectively. This not only degrades the mea-

surement accuracy, but may also affect the equality of the networks adversely and reduce the common-mode attenuation.

Construction

The probe, including its power supply, is best built on the printed-circuit board shown in **Fig. 2**. Because of the high signal frequencies likely to be encountered, mount the ICs directly on to the board: do not use sockets. A number of components must be soldered at both sides of the board. Since, for safety's sake, conductors carrying high voltages must be separated by ≥ 6 mm, remove the centre terminal of terminal block K_1 . Mount S_1 directly on to the board and solder its metal case to earth.

When all components have been fitted, three tin plate screens have to be installed: one around each of the attenuator networks and one around the active circuits. These screens are shown in **Fig. 2** and **Fig. 3**. They must be about 15 mm high and be provided with holes for ad-

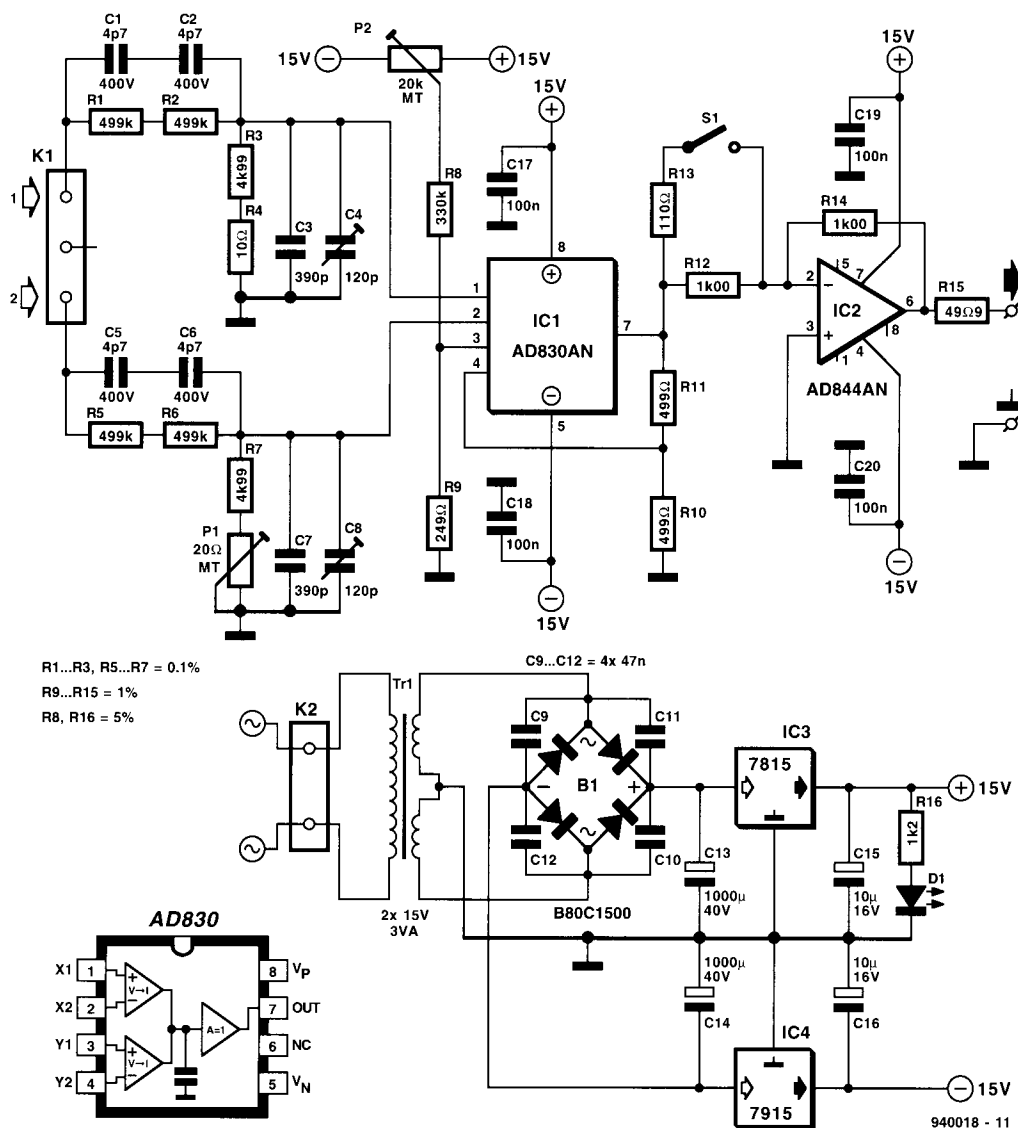


Fig. 1. Circuit diagram of the differential probe for oscilloscopes.

justing C_4 , C_8 , P_1 and P_2 , as well as for accepting the spindle of S_1 . Solder them to pins placed in suitable positions on the board. Make sure that the distance between components and screens is not less than 6 mm. Cover the compartments so formed with a tin plate lid soldered in place.

Fit a tin plate screen (of which the edges have been bent at right angles) over the track side of the board. Cover the inside of this lid with a sheet of thin polythene to ensure that the screen does not short circuit any of the tracks or solder pads.

The board is intended to be fitted in an man-made fibre enclosure of 150×80×55 mm ($6 \times 3 \frac{1}{8} \times 2 \frac{3}{16}$ in). The enclosure may be finished at the front and side as shown in Fig. 4.

Connect the prods to terminal block K_1 via 30 cm lengths of flexible multi-strand cable. Connect the probe to the oscilloscope via a 60 cm length of RG58 coaxial cable. Terminate this cable at one end into a BNC connector and solder the other end to pins PC1 and PC2 on the PCB.

Calibration

Calibration must be carried out with S_1 in position 10:1. It is advisable to let the probe warm up for about 15 minutes before starting the calibration.

Short-circuit both input terminals to earth. Connect the probe output to an oscilloscope or millivoltmeter set to its most sensitive d.c. range. Adjust P_2 until the d.c. (**off-set**) measured is zero.

Interlink the input terminals and apply a direct voltage or low-frequency voltage between this link and earth. Connect the probe output to an oscilloscope or millivoltmeter set to its most sensitive d.c. range. Adjust P_1 for zero reading. This sets the **common-mode rejection ratio** (CMRR) at low frequencies.

Connect a 1 kHz square wave signal between input 1 and earth. Connect the output of the probe to an oscilloscope. Adjust C_4 until the oscilloscope shows a neat square wave. Then do the same at input 2. This sets the **frequency compensation**.

Interlink the input terminals and con-

nect the probe output to an oscilloscope. Inject a 1 MHz sine wave signal between the linked inputs and earth. Carefully adjust C_4 and C_8 in turn until the amplitude of the signal on the oscilloscope is as small as feasible. This sets the **com-**

mon-mode rejection ratio at high frequencies. Check the setting of the frequency compensation.

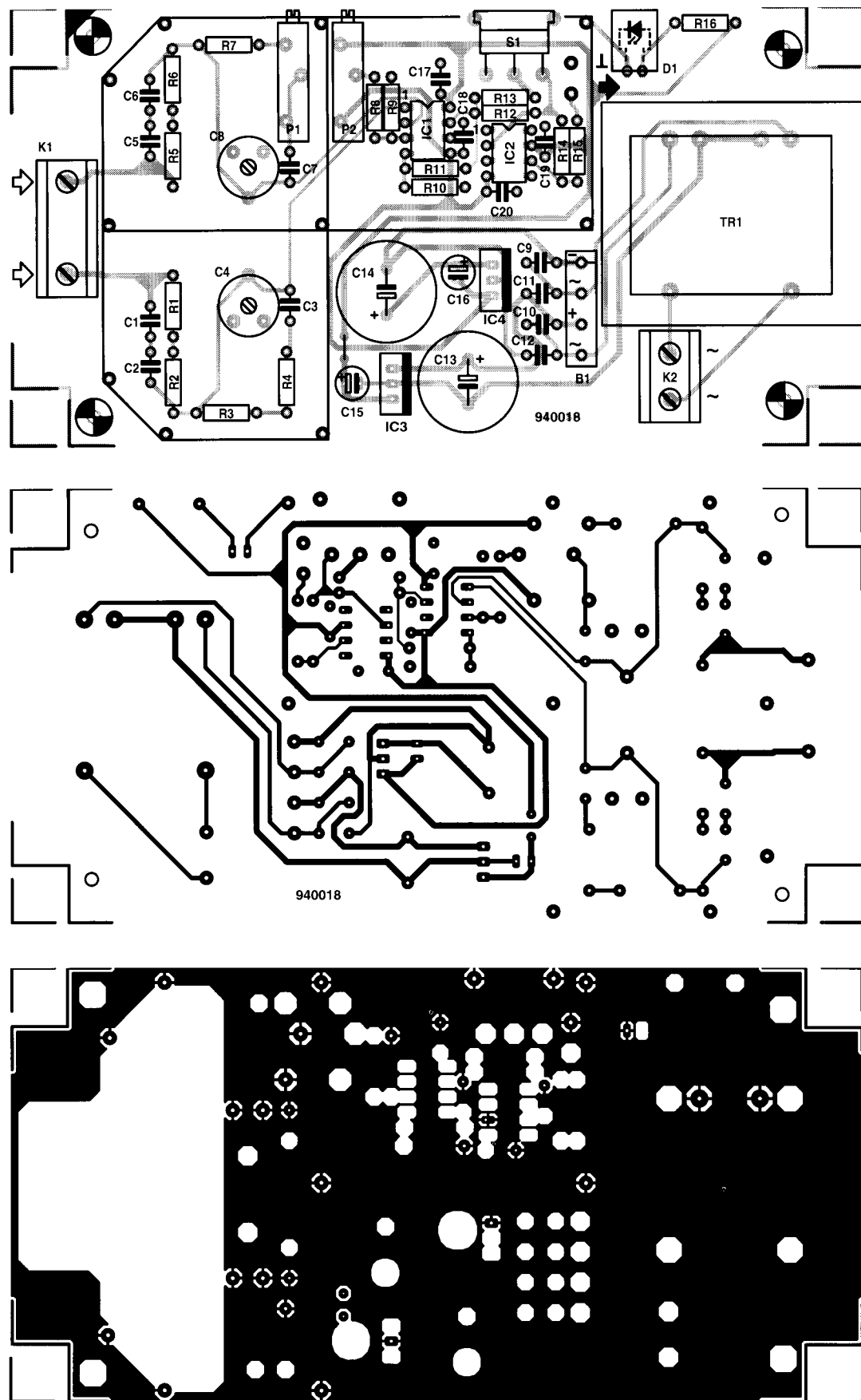


Fig. 2. Printed-circuit board for the differential probe for oscilloscopes.

Parts list

Resistors:

$R_1, R_2, R_5, R_6 = 499 \text{ k}\Omega, 0.1\%$
 $R_3, R_7 = 4.99 \text{ k}\Omega, 0.1\%$
 $R_4 = 10 \Omega, 1\%$
 $R_8 = 330 \text{ k}\Omega, 5\%$
 $R_9 = 249 \Omega, 1\%$
 $R_{10}, R_{11} = 499 \Omega, 1\%$
 $R_{12}, R_{14} = 1.00 \text{ k}\Omega, 1\%$
 $R_{13} = 110 \Omega, 1\%$
 $R_{15} = 49.9 \Omega, 1\%$
 $R_{16} = 1.2 \text{ k}\Omega, 5\%$
 $P_1 = 20 \Omega$ multiturn preset
 $P_2 = 20 \text{ k}\Omega$ multiturn preset

Capacitors:

$C_1, C_2, C_5, C_6 = 4.7 \text{ pF}, 400 \text{ V}, \text{ceramic}$
 $C_3, C_7 = 390 \text{ pF}, \text{ceramic}$
 $C_4, C_8 = 120 \text{ pF}$ trimmer
 $C_9\text{--}C_{12} = 47 \text{ nF}$
 $C_{13}, C_{14} = 100 \mu\text{F}, 40 \text{ V}, \text{radial}$
 $C_{15}, C_{16} = 10 \mu\text{F}, 16 \text{ V}, \text{radial}$
 $C_{17}\text{--}C_{20} = 100 \text{ nF}$

Semiconductors:

$B_1 = \text{B80C1500}$
 $D_1 = \text{LED}, 5 \text{ mm}, \text{red}$

Integrated circuits:

$\text{IC}_1 = \text{AD830AN}$
 $\text{IC}_2 = \text{AD844AN}$
 $\text{IC}_3 = 7815$
 $\text{IC}_4 = 7915$

Miscellaneous:

$K_1 = 3\text{-way}$ terminal block, pitch 5 mm
 (remove centre terminal)
 $K_2 = 2\text{-way}$ terminal block, pitch 7.5 mm
 $S_1 = \text{single-pole slide switch}$
 $\text{PC}_1, \text{PC}_2 = \text{solder pin}$
 $\text{Tr}_1 = \text{mains transformer}, 2 \times 15 \text{ V}, 3 \text{ VA}$
 Enclosure 150×80×55 mm
 (6×3¹/₈×2³/₁₆ in)
 (for instance Bopla Type E440BB—in
 UK available from Phoenix Mecano,
 telephone 0296 398 853)
 PCB Ref.940018

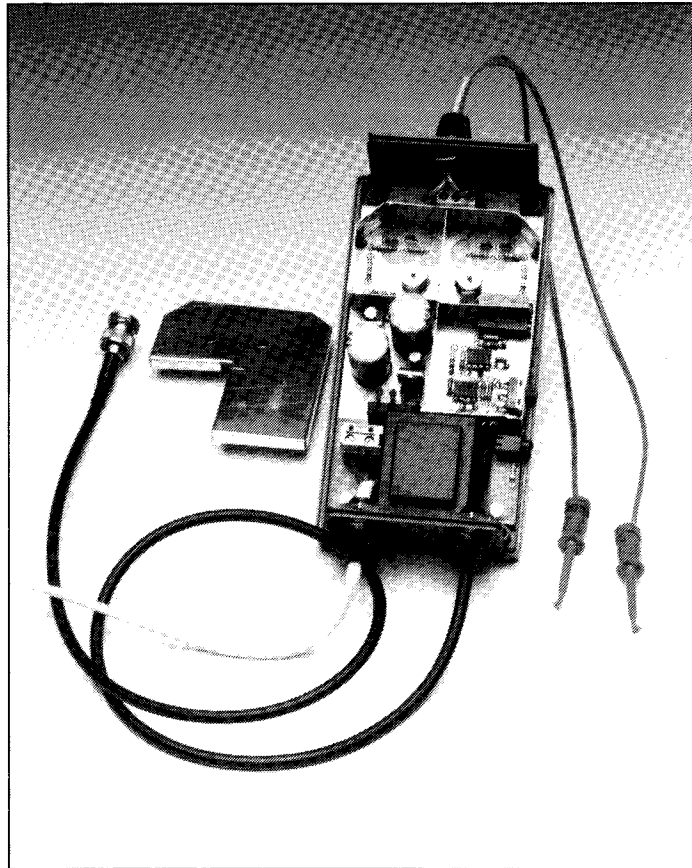


Fig. 3. Completed prototype with lid removed; note the three screened boxes.

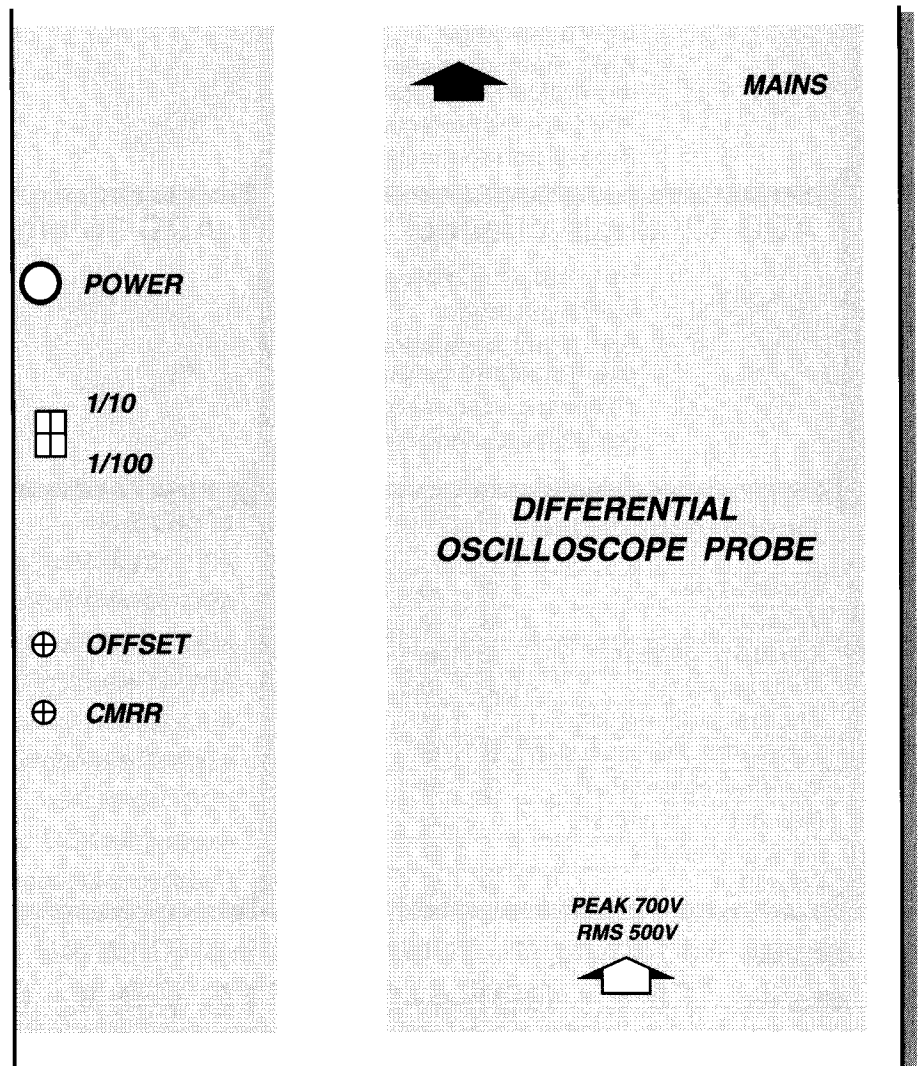


Fig. 4. Suggested side and front panel marking (not available ready made).

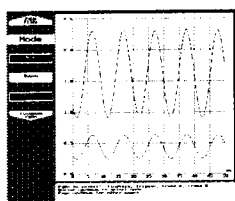
Low cost data acquisition for IBM PCs & compatibles

A unique range of easy to use data acquisition products designed for use with IBM compatible computers. Combined with the software they allow your PC to be used as a host of useful test and measurement instruments, or as an advanced data logger.

Installed in seconds they simply plug into the parallel port (except the ADC-16 which connects to the serial port). They are self contained, require no power supply and take up no expansion slots.

Each device comes with a comprehensive manual. C, Pascal and Basic drivers are included for users who wish to write their own software. Software supplied on 3.5" disk.

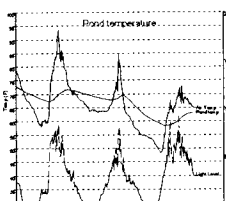
PicoScope



Scope, voltmeter, spectrum analyser

'Virtual instrument' software package. Storage oscilloscope with trigger, timebase, rulers and offset functions. Realtime spectrum analysis with min/max frequency and signal averaging. Multiple meters on screen (digital and bargraph). Printer and file handling support

PicoLog



Advanced datalogging software package

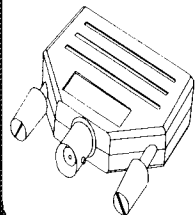
Collect, store, display and print data from 1 sample per ms to 1 per day. Record average, min/max values or scaled values (linear, equation, table look up). Report types: monitor (with min/max alarms), y-t graphs, x-y graphs, tabulation.

OVERSEAS DISTRIBUTORS WANTED:

TEL +44 954 211405

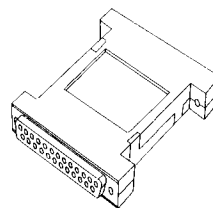
FAX +44 954 211880

ADC-10 single channel 8 bit



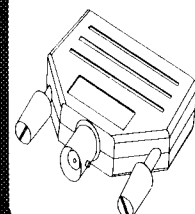
Up to 24kHz sampling rate from a 386/33MHz machine
0-5V Input range
BNC input connector allows use of standard scope probes
30V overload protection
Parallel port connection

ADC-11 eleven channel 10 bit



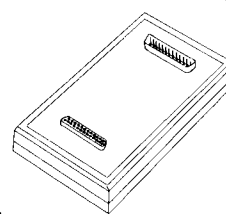
Up to 18kHz sampling rate from a 386/33MHz machine
0-2.5V Input range
Digital output
D25 input connector
30V overload protection
Parallel port connection

ADC-12 single channel 12 bit



Up to 18kHz sampling rate
0-5V Input range
BNC input connector allows use of standard scope probes
30V overload protection
Parallel port connection

ADC-16 eight channel 16 bit



Software selectable single ended or differential inputs
Resolution programmable between 8 and 16 bits + sign
 $\pm 2.5V$ input range
5V reference output
Connects to serial port

Typical application

	ADC-10	ADC-11	ADC-12	ADC-16
Oscilloscope	●	●	●	
Voltmeter	●	●	●	●
Spectrum analyser	●	●	●	
Audio sampling	●	●	●	
Chart recorder emulation		●		●
Temperature measurement	●	●	●	●
Pressure measurement	●	●	●	●
Automotive monitoring		●		●
Medical research		●	●	●
Education	●	●	●	●

Prices

ADC-10 with PicoScope	£49
ADC-10 with PicoScope and PicoLog	£59
ADC-11 with PicoScope	£85
ADC-11 with PicoScope and PicoLog	£95
ADC-12 with PicoScope	£85
ADC-12 with PicoScope and PicoLog	£95
ADC-16 with PicoLog	£109
PicoLog (for ADC-10/11/12)	£25
Oscilloscope probes (x1 x10)	£10



Pico Technology Ltd. Broadway House, 149-151 St Neots Road, Hardwick, Cambridge. CB3 7QJ.

TEL: 0954-211716 FAX: 0954-211880



Phone or FAX for sales, ordering information, data sheets, technical support. All prices exclusive of VAT.

PICO TECHNOLOGY

8051 TOOLS

ICE51

£225

Low cost entry level In-Circuit-Emulator for the 8031/51. Operates at 11Mhz 28k bytes of program memory, includes many features to aid program development but uses some resources of the target 8051.

ICE51+

£495

Advanced emulator for the 8031/51. Operation selectable up to 16MHz, 64k bytes of program memory, uses none of the target (8051) resources.

8051 "C" COMPILER

£95

Micro/C51 is an integer 'C' like compiler for the MCS51 family. Easily customised for any MCS51 family variant. High level language debugger available (£75)

8051 BOOK

£49.95

A very good text on the 8051 architecture, programming and application. The book is supplied with free (un-supported) IBM/PC based assembler and simulator.

Other tools available prices exclude VAT and delivery

Micro AMPS Limited

66 SMITHBROOK KILNS,
CRANLEIGH,
SURREY GU6 8JJ, UK

Tel: +44(0)483 268999

Fax: +44(0)483 268397



VISA

SUMMER 1993/94 CATALOGUE



NEW EDITION!

The new enlarged Catalogue is out now!

Included in this issue:

- A further 16 extra pages
- £200 worth discount vouchers
- 100's new products
- 256 pages, 26 sections, over 4000 products from some of the worlds finest manufactures and supplies
- Expanded entertainment section with in-car amps, speakers, crossovers and low cost disco equipment
- Further additions from Europe's leading kit manufacture - Velleman
- Published April 28th 1994
- Available from most large newsagents or direct from Cirkuit
- Send for your copy today!

£1.90
+ 30p p&p

Cirkuit



CIRKIT DISTRIBUTION LTD

Park Lane · Broxbourne · Hertfordshire · EN10 7NQ
Telephone (0992) 448899 · Fax (0992) 471314

WE HAVE THE WIDEST CHOICE OF USED OSCILLOSCOPES IN THE COUNTRY

TEKTRONIX 7000 SERIES OSCILLOSCOPES

AVAILABLE FROM £200

PLUG-INS SOLD SEPARATELY

TEKTRONIX 2445 4 Channel 150 MHz Delay Sweep Cursors	£1200
PHILIPS 3065 2+1 Channels 100MHz Dual TB Delay Sweep	£700
TEKTRONIX 475 Dual Trace 200 MHz Delay Sweep	£550
TEKTRONIX 485 Dual Trace 100 MHz Delay Sweep	£450
TEKTRONIX 2215 Dual Trace 60 MHz Delay Sweep	£450
TEKTRONIX 455 Dual Trace 50 MHz Delay Sweep	£400
TEKTRONIX SC504 Dual Trace 80MHz in TMS03B	£500
HITACHI V505F Dual Trace 60MHz Delay Sweep	£400
HAMEG 505 Dual Trace 80MHz Delay	£400
PHILIPS PM3217 Dual Trace 50MHz Delay Sweep	£400
GWALD 555702 Dual Trace 20MHz	£225
GWALD 05300 Dual Trace 20MHz	£200
GWALD 052508 Dual Trace 15MHz	£125
HITACHI V209 Dual Trace 20MHz Mains/Battery	£400
TELEQUIPMENT 032 Dual Trace 10MHz Mains/Battery	£200
TEKTRONIX 2430 Dual Trace 150MHz Digital Storage	£2000
TEKTRONIX 456 Dual Trace 100MHz Delay Sweep Analogue Storage	£450
H.P. 1740A Dual Trace 100MHz Delay Sweep Analogue Storage	£450

PHILIPS PM5193 Programmable synthesizer/
Function Generator 0.1MHZ - 50MHZ IEEE-488.
As new £1500

MARCONI 2018 Synthesised AM/FM Sig Gen 80kHz-520MHz	£900
RACAL 9081 Synthesised Sig Gen 1.5 - 520MHz	£600
ELP/DANA 341D Microwave Frequency Counter 20Hz - 18GHz	£950
RACAL/DANA 1991Nanosecond Universal Counter	£800
RACAL 9302 RF Millivoltmeter True RMS 10kHz 1.5GHz	£450
RACAL 9301A RF Millivoltmeter True RMS 10kHz 1.5GHz	£300
RACAL 9009 Automatic Mod. Meter 10MHz/1.5GHz Wide Deviation	£250
LYONS PG73N Pulse Gen. PRF 1Hz - 20MHz	£150
KEITHLEY 224 Programmable Current Source	£1000
FARNELL PSG520 Syn. AM/FM Sig. Gen 100kHz - 520MHz	£800
PHILIPS PM6309 DISTORTION Meter 0.01%	£300
H.P. 15341A Frequency Counter 50MHz - 4.5GHz	£500
RACAL 1998 Ref Counter 1.5GHz (GPIB & High Stab)	£900
GAY MILANO Line Voltage Analyser	£500
H.P. 7470A Potter 2 pen HPFB	£200

BRUEL & KJOER Vibration Exciter System
Consisting of Exciter Control 1047: Power Amp
2708 & Exciter Body 4802 (up to 1780N - 400lbf)
OTHER B&K EQUIPMENT AVAILABLE

SPECTRUM ANALYSERS

H.P. 141T with 8555A & IF Plug-In 10MHz - 18GHz	£1800
H.P. 141T with 8554B & 8552B 500kHz - 1250MHz	£1300
H.P. 141T with 8554L & 8552A 500kHz - 1250MHz	£1000
H.P. 141T with 8556A & 8552B 20Hz - 300kHz	£1000
H.P. 140T with 8553B & 8552A 160Hz - 110MHz	£800
MARCONI TF2370 1kHz - 110MHz	£1500
H.P. 182C with 8558B 100Hz - 1500MHz	£1500

H.P. 8640B Sig. Gen 20Hz - 1024MHz	£1500
H.P. 8620C Sweep Osc. with 86245A 5.912-4GHz	£750
MARCONI Digital Freq. Meter 20Hz	£900
BRADLEY 152 Oscilloscope Calibrator	£600
WILTRON 500 Scaler Network Analyser with Detectors	£1000
FERRROGRAPH Audio Test Set with ATU	£550
LINDON LA1 MK2B Audio Analyser	£500
DATRON 1061A - 6.5 digit true RMS AC Current	£1250
DATRON 1065 Multimeter AC/DC ohms IEEE	£600
HEWLETT PACKARD 3490A Bench Multimeter, 5 Digit AC/DC/Ohms	£200
PHILIPS PM2534 Multi Function DMM 3.5 - 6.5 digit with GPIB/IEEE	Only £450

MARCONI Digital Frequency Meter 2430A 10Hz-80MHz	£125
MARCONI Digital Frequency Meter 2431A 10Hz-200MHz	£150
LINDON LA1 MK2B Audio Analyser	£175
MARCONI Universal Counter Timer 2438 DC - 520MHz	£225
BLACK STAR Jupiter 500 Sine/Sq/Tri 0.1Hz-500kHz	£70
THANDAR TG101 Func. Gen. 0.02Hz-200kHz Sine/Sq/Tri/TTL	£60

SOLARTRON/SCHLUMBER 1250 FREQUENCY RESPONSE ANALYSER..... £3500

H.P. 8630B Sweep Osc. with 86974 Plug-in 26.5-40GHz	£300
RACAL/DANA RF Power Meter 9104	£400
WAYNE KERR B605 Automatic Precision Bridge 0.05%	£900
WAYNE KERR B605 Automatic Component Bridge 0.1%	£900
WAYNE KERR B424 Digital LCR Meter	£125
COSSOR 108L Optical Cable Fault Locator	£1500
BICOTEST T431M Cable Test Set	£1000
FARNELL PSU TNS70MK2 70V 5A/30V 10A	£300
FARNELL PSU H60/25 0-60V/0.25Amps Metered	£400
FARNELL B30/20 0-30V, 20Amps	£250
FARNELL B20/10 0-30V, 10Amps	£200
BRANDENBURG 472R PSU +/- 2KV	£200
MARCONI TF2700 Universal LCR Bridge, Battery from	£150
FARNELL LA520 RF Power Amp, 1.5-520MHz 300mW	£175
RACAL 9100 Absorption Wattmeter 1MHz-1GHz 3W	£100
KIKUSUI AVM23 AC Voltmeter Dual 10Hz - 500MHz	£70
AVO Valve Tester GT150	£15

FARNELL ISOLATING TRANSFORMERS GU500 240V 500VA Un-Used £50 ISOLATING TRANSFORMERS 500VA Un-Cased £30

NEW EQUIPMENT

HAMEG OSCILLOSCOPE HM 1005 Triple Trace 100MHz	
Delay Timebase	£847
HAMEG OSCILLOSCOPE HM 804 Dual Trace 60MHz	
Delay Sweep	£653
HAMEG OSCILLOSCOPE HM203 7 Dual Trace 20MHz	
Component Tester	£362
HAMEG OSCILLOSCOPE HM205 3 Dual Trace 20MHz	
Digital Storage	£653

All other models available: all oscilloscopes supplied with 2 probes

BLACK STAR EQUIPMENT (p&p all units £5)	
APOLLO 10 100MHz Counter Timer Ratio/Period/Time Interval etc	£222
APOLLO 100 100MHz (As above with more functions)	£225
METEOR 100 FREQUENCY COUNTER 100MHz	£119
METEOR 600 FREQUENCY COUNTER 600MHz	£145
METEOR 1000 FREQUENCY COUNTER 1GHz	£189
JUPITOR 500 FUNCTION GENERATOR 0.1 Hz-500kHz Sine/Sq/Tri	£119
ORION COLOUR BAR GENERATOR Pal/TV/Video	£229
All other Black Star Equipment available	
OSCILLOSCOPE PROBES Switchable x1 x10 (P&P £3)	£12

Used Equipment Guaranteed- Manuals supplied if possible
This is a VERY SMALL SAMPLE OF STOCK. SAE or Telephone for lists. Please check availability before ordering CARRIAGE all units £16
VAT to be added to Total of Goods and Carriage

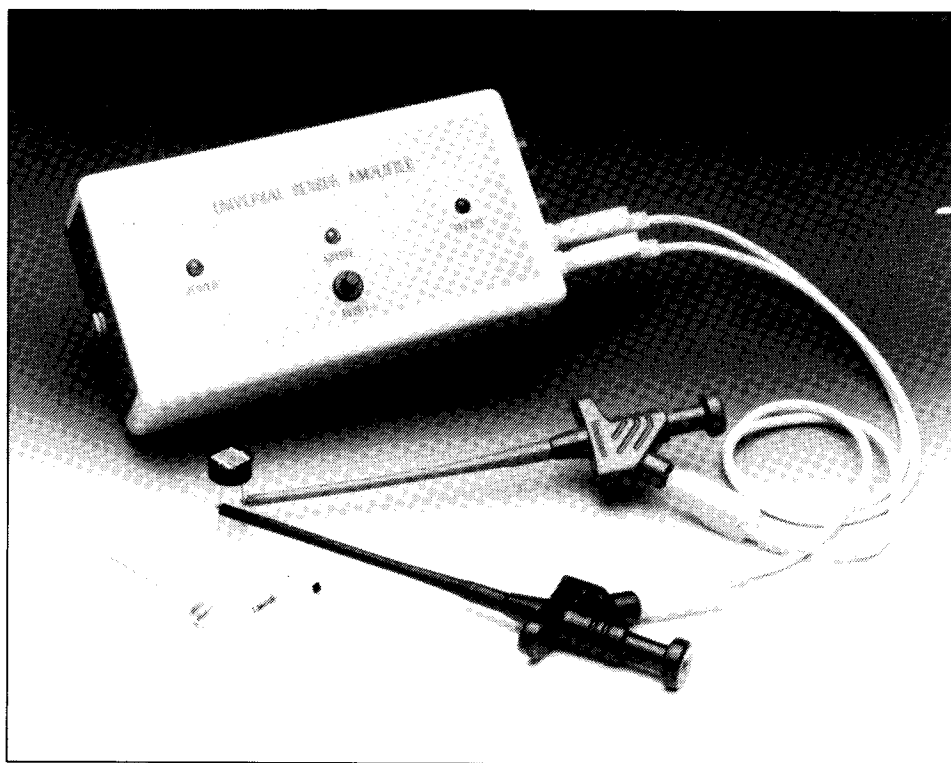
STEWART OF READING

110 WYKEHAM ROAD, READING, BERKS RG6 1PL

Telephone: (0734) 268041 Fax (0734) 351696 Callers Welcome 9am-5.30pm Mon-Fri (until 8pm Thurs)



GENERAL PURPOSE SENSOR MONITOR



Sensors and transducers are interesting electronic devices to work with, but the snag is that their output signal invariably requires a made-to-measure amplifier that enables an indicator circuit to be driven. LDRs, temperature sensors, strain gauges, they all need an amplifier with very specific characteristics. The amplifier described here is designed to handle almost any sensor signal, has adjustable switching thresholds, and will be invaluable for quick experiments with a wide variety of sensors, both polarized and unpolarized.

Design by M. Haas

THE heart of the circuit shown in **Fig. 1** is formed by the trusty 741 opamp, IC₄. Here, the 741 is wired as a comparator with hysteresis. The sensor voltage arrives at the non-inverting input, pin 3, via a low-pass filter, R₄-C₃, which serves to suppress fast signal variations. The inverting input of the opamp, pin 2, is held at a reference level which is adjustable with preset P₁. As long as the voltage on pin 3 is lower than that on pin 2, the output of

the 741, pin 6, will remain low (approx. 0 V). The output swings high (to about 10 V) if the voltage on pin 3 is higher than that on pin 2.

Hysteresis is introduced by R₇ and P₂ which feed a small portion of the output voltage back to the input. The opamp output voltage is fed to two NAND Schmitt trigger gates, IC_{1c} and IC_{1d}, via low-pass filter R₈-C₅. The two gates are inverters, and allow a single jumper to select between a relay which

is normally energized or normally off. The choice between jumper A or B depends on the comparator's output level under normal conditions, and, thus, on the type of sensor used.

The relay is driven by transistor T₁ via resistor R₉. LED D₂ gives an extra indication of the current relay state (on or off). Since the relay coil current is greater than the maximum permissible current through the LED, the two devices can not be connected in series just like that. Shunt resistor R₁₀ prevents a too high voltage across the LED (i.e., too much current through the device).

The relay contacts are brought out to pins on connector K₂. The pin marked 'P' is the pole, while 'NO' and 'NC' mark the normally open and normally closed contact respectively.

Although the contacts of the relay mentioned in the parts list are, in principle, capable of switching the mains voltage, that should not be attempted for the sake of safety. If you still wish to switch mains operated loads, mount the relay off the board, in a separate, ABS, enclosure. For the sake of safety, use grommets and strain reliefs for the mains wiring, and isolate the relay pins with heat-shrink sleeving.

Bistable

The output signal of the comparator is also used to clock a D-type bistable, IC_{2b}. Because the D (data) input of the bistable (pin 9) is tied permanently to the +10-V supply rail, the Q output will go high on the first positive-going edge of the clock signal. The high level of Q is used to drive T₂ into saturation, whereupon LED D₃ lights. That condition is maintained until the circuit is reset manually by pressing switch S₁. The LED so indicates that the circuit was actuated at least once, which is very useful if it is used as a sensor monitor which operates unattended for long periods. Note that such a memory function can not be obtained from the relay, because that is simply a 'slave' to the comparator output.

Inputs

The input of the sensor monitor consists of four electronic switches, IC_{3a}-IC_{3d}, and an oscillator built around IC_{1a} and IC_{1b}. The oscillator supplies a square wave signal with a frequency of

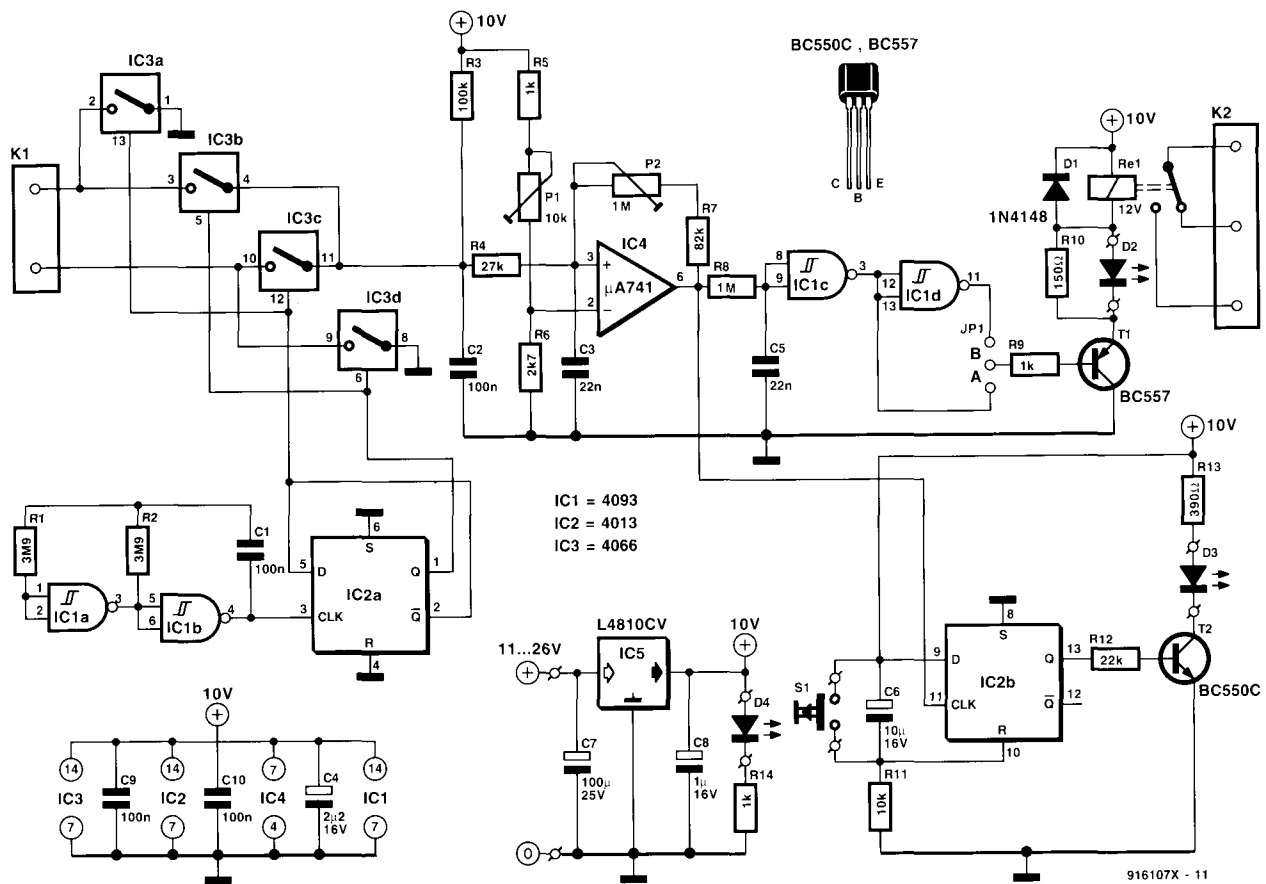


Fig. 1. The circuit consists of a comparator, a relay, and four electronic switches driven by an oscillator.

about 1 Hz. This signal is fed to bistable IC_{2a}, which divides it by two, and provides two complementary output signals with a frequency of 0.5 Hz, and a duty factor of 0.5. These signals are available on outputs Q (pin 1) and $\bar{Q}$ (pin 2), and control the four electronic switches contained in IC₃.

Assuming that output Q is high, and $\bar{Q}$ low, switches IC_{3b} and IC_{3d} are closed, and the other two, open. In other words, the 'left-hand' side of the sensor (which is wired to K₁), is connected to the +10 V line via IC_{3b} and resistor R₃, while the 'right-hand' side is taken to ground via IC_{3d}.

One second later, this situation is reversed: the $\bar{Q}$ output of IC_{2a} is logic high, switches IC_{3a} and IC_{3c} are closed, and the other two, opened. The right-hand side of the sensor is then connected to the +10-V rail via IC_{3c} and R₃, while the other side is connected to ground via IC_{3a}. In other words, the sensor connections are 'reversed' at a rate of 0.5 Hz. The purpose of this arrangement will be discussed further on.

Low-pass filter R₄-C₃ prevents the comparator from noticing the opening and closing of the electronic switches

(unless the sensor is a polarized type, which will also be reverted to below).

Power supply

The circuit is powered by a ready-made mains adaptor, which is safer and (in many cases) less expensive than a separate transformer. The type of adaptor required is one with a direct output voltage between 11 V and 26 V. The adaptor output is stepped down to 10 V by a three-pin fixed voltage regulator Type L4810. The more common 7810 is not used here because it would require an input voltage of at least 13 V, which means that at least 3 V is 'wasted'. By contrast, the L4810 introduces a voltage drop of only 1 V, which means that less supply power is needed.

Applications

To start with, it is, of course, possible to use two electrodes to form a sensor. This could be used to monitor the conductivity or concentration of a certain solution. Alternatively, you may want to use an LDR (light-dependent resistor), which has a high resistance in the

dark, and a low resistance in the light. Consequently, the sensor voltage at the comparator input will be high in the dark, and low in the light.

A potentiometer may also be used as a positioning sensor to check the operation of a mechanical device. For temperature measurements, an NTC (negative temperature coefficient) or a PTC (positive temperature coefficient) resistor may be connected up.

The above sensors are all non-polarized. Consequently, they pass current in both directions, and may be connected both ways around. Polarized sensors may also be used. The simplest of these is created by connecting a diode in series with the previously mentioned LDR. Consequently, current can flow in one direction only. That has the following effect: as it grows dark, the sensor voltage rises to a level where the comparator toggles, and the relay is energized (or de-energized, depending on which jumper is fitted). However, as soon as the polarity of the sensor is reversed (by the oscillator and the electronic switches), the comparator will toggle again. This on/off change is repeated over and over again, so that the relay is switched on and off

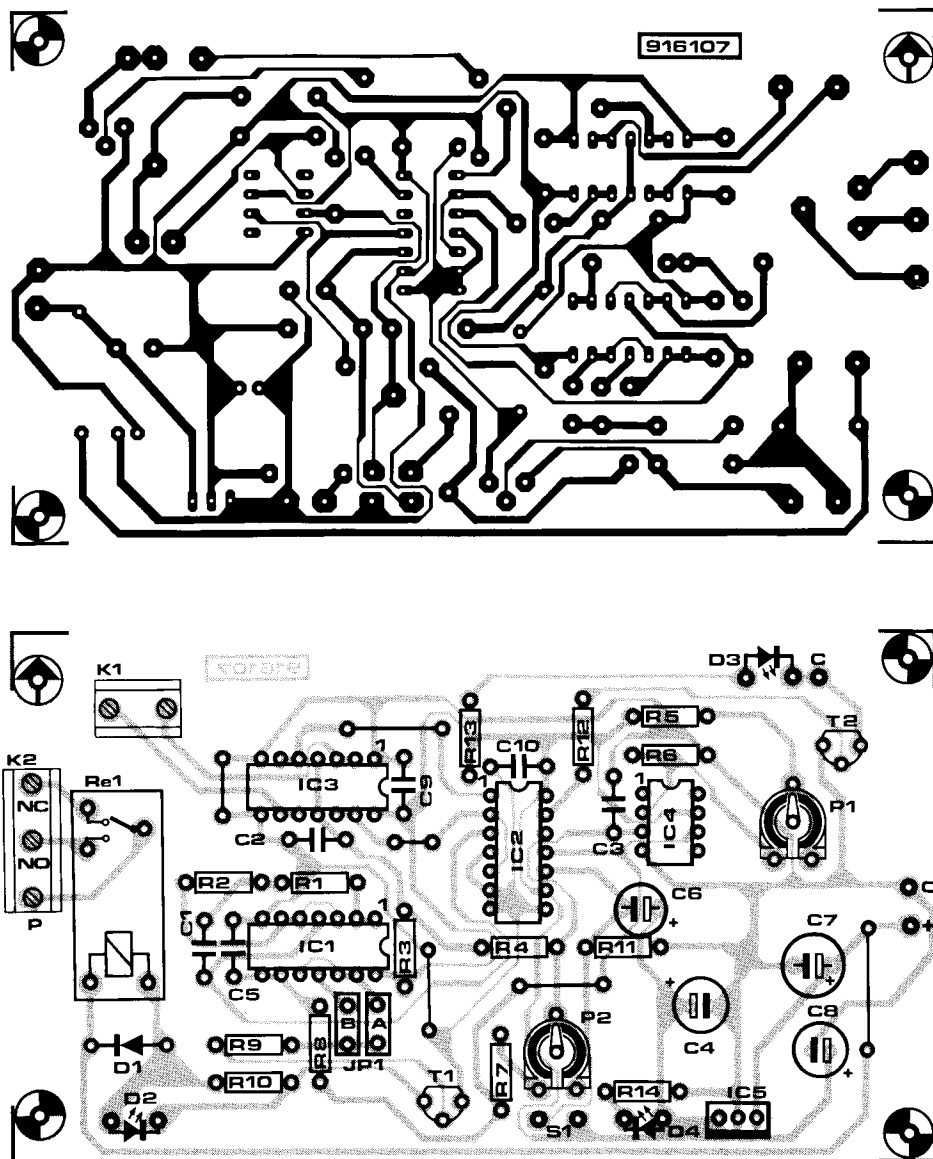


Fig. 2. Track layout (direct reading) and component mounting plan of the PCB designed for the sensor monitor (PCB not available ready-made).

at a rate of 0.5 Hz. In certain cases, this may boost the attention drawing effect of, for instance, an alarm siren connected to the relay contacts. The 'trick' may also be applied to the previously mentioned 'positioning' potentiometer.

A photodiode forms a polarized sensor without the help of an extra diode. Photodiodes may be connected either way around, taking into account that the operation of the relay changes 180 degrees. The same may, of course, be achieved by moving the jumper to the other position, or by swapping the NO and NC relay contacts.

Construction

The artwork of the printed circuit board designed for the sensor monitor is shown in **Fig. 2**. Unfortunately, this board is not available ready-made through the Readers Services, so that you have to produce it yourself from the drawings given, or build the circuit on prototyping board.

The board is populated in the usual way, that is, starting with the wire links and the low-profile parts, followed by the taller parts. The ICs are fitted last.

After a careful check on the solder work and the orientation of the polar-

COMPONENTS LIST

Resistors:

R1, R2 = 3M Ω
 R3 = 100k Ω
 R4 = 27k Ω
 R5, R9, R14 = 1k Ω
 R6 = 2k Ω
 R7 = 82k Ω
 R8 = 1M Ω
 R10 = 150 Ω
 R11 = 10k Ω
 R12 = 22k Ω
 R13 = 390 Ω
 P1 = preset 10k Ω
 P2 = preset 1M Ω

Capacitors:

C1, C2, C9, C10 = 100nF
 C3, C5 = 22nF
 C4 = 2 μ 2 16V radial
 C6 = 10 μ F 16V radial
 C7 = 100 μ F 63V radial
 C8 = 1 μ F 16V radial

Semiconductors:

D1 = 1N4148
 D2, D4 = LED red 3mm
 D3 = LED green 3mm
 T1 = BC557
 T2 = BC550C
 IC1 = 4093
 IC2 = 4013
 IC3 = 4066
 IC4 = 741
 IC5 = L4810

Miscellaneous:

K1 = 2-way PCB terminal block, raster 7.5mm.
 K2 = 3-way PCB terminal block, raster 7.5mm.
 S1 = SPST push-button.
 Re1 = PCB mount relay, 12V, e.g. Siemens V23127-B0002-A101.
 Mains adaptor socket.
 Case: e.g., OKW A9030087 (150x80x50mm).

ized components, the board may be fitted into suitable enclosure. The photograph in **Fig. 3** shows our prototype, which may give you further ideas as regards construction. The circuit is then almost ready for use.

Adjustment

The reference voltage at the inverting input of the comparator may be varied between about 2 V and 7.3 V with preset P1. To enable the comparator to toggle, the sensor output voltage must lie in this range. Remember, the sensor forms a voltage divider together with R3 (100 k Ω). Consequently, to enable a



ESR ELECTRONIC COMPONENTS

Station Road, Cullercoats,

Wear NE30 4PQ

Tel. 091 251 4363

Fax. 091 252 2296

DEPT. EE

74LS Series				4000 Series				TRANSISTORS				LINEAR ICs				SOLDERING IRONS				RF CONNECTORS			
74LS00	E0.22	4000	E0.17	2N1613	E0.31	BC186	E0.33	BD534	E0.47	CA311E	E0.28	Antex Soldering irons								BNC Solder Plug 50R	E0.93		
74LS01	E0.14	4001	E0.21	2N1711	E0.26	BC204C	E0.72	BD535	E0.48	CA32A	E0.25	M 12 Watt	E0.75							BNC Solder Plug 75R	E0.96		
74LS02	E0.14	4002	E0.17	2N1893	E0.29	BC206B	E0.72	BD536	E0.65	CA355	E0.22	C 15Watt	E0.78							BNC Crimp Plug 50R	E0.68		
74LS03	E0.06	4006	E0.17	2N2118A	E0.28	BC211A	E0.72	BD540	E0.65	CA741CE	E0.28	G 18Watt	E0.96							BNC Crimp Plug 75R	E0.68		
74LS04	E0.14	4007	E0.28	2N2219A	E0.25	BC208	E0.72	BD648	E0.52	CA747CE	E0.39	CS 17Watt	E0.88							BNC Solder Skt	E1.08		
74LS05	E0.14	4008	E0.31	2N2222A	E0.16	BC209A	E0.72	BD650	E0.53	CA3046	E0.37	XS 25Watt	E0.96							BNC Chassis Skt	E0.80		
74LS08	E0.14	4009	E0.19	2N2646	E0.80	BC212	E0.08	BD707	E0.42	CA3080	E0.72	ST4 STAND	E2.85							PL259 5mm	E0.68		
74LS09	E0.14	4010	E0.23	2N2904A	E0.25	BC221L	E0.08	BD807	E0.80	CA3130	E0.88	Desolder: Gas Iron	E1.11							PL259 5mm	E0.68		
74LS10	E0.14	4011	E0.23	2N2905A	E0.23	BC221BL	E0.08	BD831	E0.78	CA3130E	E0.96	Desolder: Pump	E0.96							PL259 5mm	E0.68		
74LS11	E0.12	4012	E0.16	2N2907	E0.07	BC213	E0.08	BD833C	E0.46	CA3140	E0.88	Antistatic Pump	E4.30							RND UHF socket	E0.68		
74LS107	E0.23	4013	E0.21	2N2926	E0.16	BC213CL	E0.08	BDX34C	E0.50	CA3240	E0.22	225W 0.5kg Solder	E0.96							SQR UHF socket	E0.45		
74LS108	E0.21	4014	E0.30	2N3053	E0.27	BC214	E0.08	BDX53C	E0.47	ICL7621	E1.70	185W 0.5kg Solder	E0.60							F Plug RG58	E0.30		
74LS112	E0.21	4015	E0.31	2N3054	E0.90	BC214L	E0.08	BDX54C	E0.50	ICM7555	E0.43	1mm 3 yds Solder	E0.96							N Socket RG8	E1.40		
74LS113	E0.21	4016	E0.18	2N3055	E0.62	BC237B	E0.09	BF180	E0.31	ICM7556	E0.96	Desolder: Braid	E0.87							BNC Crimp Pliers	E1.50		
74LS114	E0.21	4017	E0.27	2N3440	E0.12	BC237C	E0.09	BF185	E0.31	ICM7556	E0.96												
74LS12	E0.14	4019	E0.19	2N3703	E0.10	BC251	E0.13	BF194	E0.19	LF351N	E0.36												
74LS122	E0.31	4020	E0.31	2N3704	E0.10	BC252	E0.13	BF195	E0.19	LF353	E0.41												
74LS123	E0.31	4021	E0.31	2N3705	E0.10	BC261B	E0.24	BF244	E0.35	LM358N	E0.27												
74LS125	E0.21	4022	E0.32	2N3706	E0.10	BC262B	E0.24	BF257	E0.33	LM33	E0.27												
74LS126	E0.21	4022	E0.32	2N3706	E0.10	BC262B	E0.24	BF257	E0.33	LM33	E0.27												
74LS13	E0.14	4023	E0.16	2N3711	E0.14	BC267B	E0.09	BF259	E0.37	LM3800	E1.12												
74LS132	E0.21	4024	E0.25	2N3773	E1.51	BC307	E0.10	BF337	E0.36	LM381	E1.22												
74LS133	E0.18	4025	E0.15	2N3773	E1.79	BC308	E0.10	BF355	E0.38	LM386	E0.48												
74LS136	E0.16	4027	E0.18	2N3819	E0.40	BC327	E0.10	BF423	E0.13	LM387	E1.60												
74LS138	E0.16	4028	E0.22	2N3820	E0.58	BC328	E0.10	BF451	E0.19	LM392N	E0.79												
74LS139	E0.16	4028	E0.22	2N3904	E0.10	BC337	E0.10	BF459	E0.19	LM393	E0.28												
74LS14	E0.16	4029	E0.36	2N3906	E0.10	BC338	E0.10	BF469	E0.36	LM748CN	E1.98												
74LS145	E0.58	4030	E0.70	2N4036	E0.31	BC414C	E0.13	BFX29	E0.29	LM1458	E0.72												
74LS147	E1.26	4033	E0.56	2N5296	E0.57	BC461	E0.40	BFX85	E0.31	LM3914	E2.70												
74LS148	E0.10	4034	E0.24	2N5321	E0.57	BC463	E0.29	BFV50	E0.29	LM3915	E2.70												
74LS15	E0.25	4035	E0.31	2N5107	E0.42	BC465	E0.29	BFV51	E0.29	LM3916	E2.70												
74LS151	E0.15	4040	E0.29	AC127	E0.30	BC479	E0.32	BFV52	E0.28	MC4558	E0.36												
74LS153	E0.25	4040	E0.29	AC127	E0.30	BC490	E0.24	BS107	E0.21	NE531	E1.56												
74LS154	E0.20	4042	E0.22	AC128	E0.28	BC516	E0.22	BS170	E0.21	NE556N	E0.36												
74LS155	E0.25	4043	E0.28	AC187	E0.45	BC517	E0.20	BSW66	E1.35	NE567N	E0.36												
74LS156	E0.36	4044	E0.35	AC188	E0.37	BC527	E0.20	BU126	E0.20	NE553	E0.36												
74LS157	E0.25	4047	E0.25	AD149	E1.67	BC537	E0.20	BU209	E1.82	NE554	E0.66												
74LS158	E0.25	4047	E0.25	AD161	E0.92	BC546C	E0.09	BU281	E1.73	TBA1203	E0.77												
74LS160	E0.32	4048	E0.30	AD162	E0.92	BC547C	E0.08	BU326A	E1.80	TBA810S	E0.68												
74LS161	E0.32	4049	E0.20	BC107	E0.14	BC558C	E0.08	BU500A	E1.76	TD42030	E1.35												
74LS162	E0.32	4050	E0.20	BC107	E0.14	BC559C	E0.08	BU525	E1.24	TL001	E0.35												
74LS163	E0.32	4051	E0.36	BC108	E0.13	BC550C	E0.08	BU806	E1.36	TL062	E1.42												
74LS164	E0.26	4052	E0.25	BC108A	E0.14	BC556A	E0.08	BUX84	E0.78	TL064	E0.46												
74LS165	E0.48	4053	E0.25	BC108C	E0.16	BC557C	E0.08	IRF540	E1.60	TL071CP	E0.32												
74LS166	E0.36	4054	E0.36	BC109	E0.14	BC558C	E0.08	IRF740	E1.63	TL072CP	E0.34												
74LS173	E0.24	4055	E0.36	BC109C	E0.16	BC559C	E0.08	MJ111016	E2.11	TL074CN	E0.36												
74LS174	E0.24	4055	E0.36	BC111A	E0.41	BC560B	E0.09	MJ11016	E2.11	TL081	E0.33												
74LS175	E0.24	4063	E0.29	BC115	E0.41	BC637	E0.21	MJ2501	E1.60	TL082CP	E0.34												
74LS190	E0.25	4066	E0.18	BC116	E0.41	BC638	E0.21	MJ3001	E1.52	TL084CN	E0.36												
74LS191	E0.26	4067	E1.91	BC118	E0.41	BC639	E0.21	MJ3400	E0.40	UAL733	E0.64												
74LS192	E0.42	4068	E0.16	BC132	E0.36	BC640	E0.21	MJ3500	E0.42	UA1900	E0.52												
74LS193	E0.24	4069	E0.20	BC133	E0.36	BC641	E0.21	MJ3500	E0.42	UA1900	E0.52												
74LS195	E0.24	4070	E0.17	BC135	E0.36	BCY71	E0.20	MPS442	E0.17	ZN425E	E0.48												
74LS196	E0.24	4071	E0.20	BC140	E0.25	BCY72	E0.20	MRF475	E0.21	ZN425E	E0.68												
74LS197	E0.24	4072	E0.17	BC141	E0.27	BD135	E0.20	TI2121	E0.35	ZN426E	E0.61												
74LS200	E0.16	4073	E0.17	BC142	E0.31	BD136	E0.21	TI2122	E0.37	ZN427E	E2.82												
74LS21	E0.14	4074	E0.17	BC143	E0.34	BD137	E0.22	TI2123	E0.37	ZN428E	E6.12												
74LS22	E0.14	4075	E0.30	BC149	E0.34	BD138	E0.22	TI2127	E0.37	ZN435E	E5.31												
74LS221	E0.36	4077	E0.17	BC154	E0.36	BD139	E0.23	TI2132	E0.46	ZN448E	E7.92												
74LS240	E0.32	4081	E0.14	BC157	E0.12	BD140	E0.24	TI2137	E0.46														
74LS241	E0.32	4082	E0.21	BC159	E0.12	BD150C	E0.82	TI2142	E1.08														
74LS242	E0.32	4085	E0.28	BC160	E0.28	BD151	E0.82	TI2147	E1.42														
74LS243	E0.32	4089	E0.28	BC161	E0.28	BD152	E0.82	TI2152	E1.32														
74LS244	E0.32	4089	E0.55	BC170B	E0.16	BD187	E0.39	TI295C	E0.63														
74LS245	E0.36	4093	E0.18	BC171	E0.11	BD201	E0.40	TI3055	E0.63														
74LS247	E0.32	4094	E0.31	BC171B	E0.16	BD202	E0.40	TI3030C	E0.31														
74LS251	E0.24	4095	E0.56	BC172	E0.13	BD203	E0.40	TI313C	E0.34														
74LS257	E0.24	4097	E0.10	BC178	E0.13	BD204	E0.40	TI323C	E0.32														
74LS258	E0.24	4099	E0.38	BC177	E0.18	BD222	E0.40	TI333C	E0.72	2178.20	E3.69												
74LS26	E0.14	4052	E0.38	BC178	E0.18	BD225	E0.42	TI4P1A	E0.36	27C128-20	E3.31												
74LS266	E0.14	4053	E0.31	BC179	E0.17	BD232	E0.38	TI4P2C	E0.38	27C128-20	E3.31												
74LS27	E0.14	4503	E0.31	BC182	E0.08	BD237	E0.32	TI4P7	E0.48														
74LS273	E0.32	4508	E0.90	BC182L	E0.08	BD23																	

CALL IN – OPEN: MON-FRI 8.30-5.00 SAT 10.00-5.00

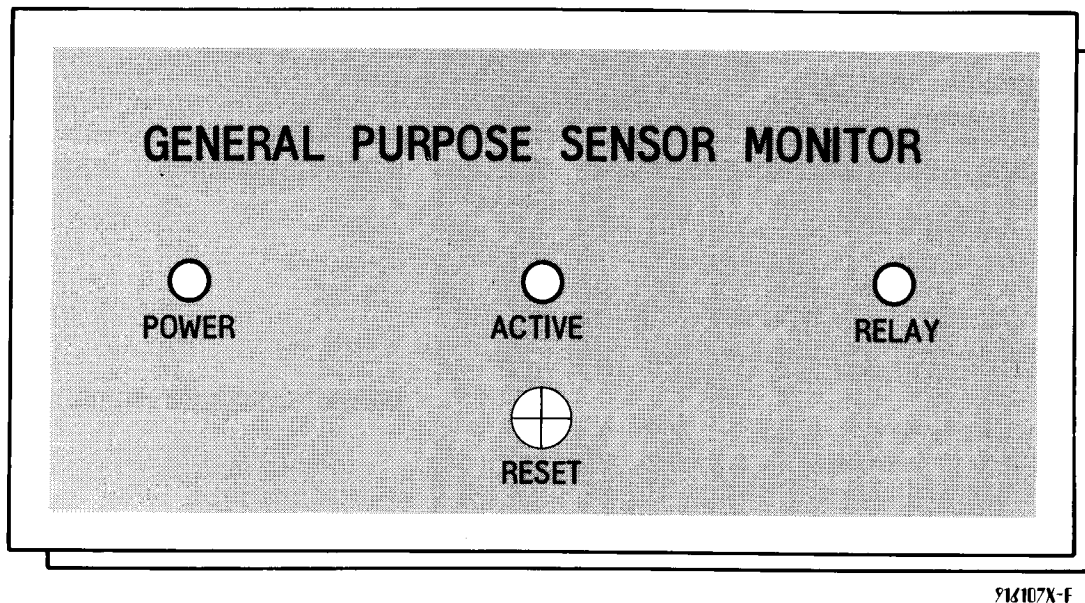


Fig. 3. Suggested front panel layout.

suitable switching threshold to be set, the sensor must have an impedance between about 32 k Ω and 270 k Ω . A sensor having an impedance of between 10 k Ω and 20 k Ω is, therefore, not suitable straight away, because then the voltage at the non-inverting input of the comparator can never become high enough for the comparator to toggle. If you still want to use such a sensor, you have to change the value of R_3 to satisfy the following two equations:

$$R_{\text{sens(min)}}/(R_{\text{sens(min)}}+R_3) \times 10 \text{ V} \approx 2 \text{ V};$$

and

$$R_{\text{sens(max)}}/(R_{\text{sens(max)}}+R_3) \times 10 \text{ V} \approx 7.3 \text{ V}.$$

Briefly, this means that the voltage divider formed by R_3 and the sensor has to be calculated again, whereupon the switching threshold and the amount of hysteresis can be adjusted with P_1 and P_2 respectively.

Correct adjustments of these two presets is awarded with good sensitive and an accurate switching point without relay 'chatter'.

Electrodes

Measuring the concentration of a saline solution is possible by measur-

ing its conductivity. Two electrodes (for instance, copper ones) are immersed in the solution, a current is sent through them, and the voltage drop is measured. Since pure water does not conduct, the resistance formed by the solution, and therefore the voltage across the electrodes, is a measure of the concentration of 'salt' ions in the solution. Ordinary tap water conducts only because it contains a fair concentration of dissolved salts, and, therefore, many (positive or negative) ions.

The sensor monitor could be used to keep a continuous check on a certain concentration level. Unfortunately, electrolysis occurs readily if a direct current is sent through the electrodes. Electrolysis causes a number of chemical reactions to occur at the electrodes. The result is usually gas, the gradual dissolving of one electrode, and deposits of metal ions on the other electrode. Obviously, these effects can easily distort the results of the conductivity measurement.

Fortunately, the above problems are easily avoided by using alternating current instead of direct current. In practice, this minimizes the effects of electrolysis at the electrodes, provided the frequency of the current is high enough. It seems that about 100 Hz is the absolute minimum for such measurements, which means that the 0.5-Hz signal produced in the switching circuit at the input of the present monitor is wide off the mark. To change the switching frequency to about 100 Hz, the values of the timing components in the oscillator are modified as follows: $R_1=R_2=39 \text{ k}\Omega$; $C_1=10 \text{ nF}$. Professional instruments of this type often use a much higher switching frequency: up to 10 kHz! ■

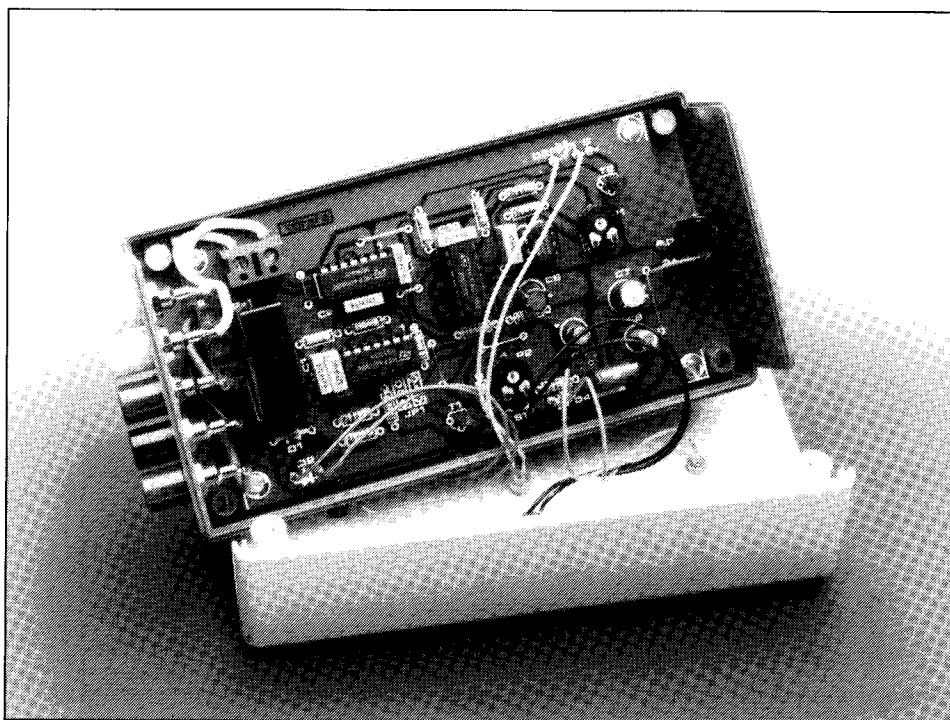


Fig. 4. Completed prototype.

80C535 HARDWARE/ASSEMBLER COURSE

PART 3: INTRODUCTION TO COMPARE/CAPTURE UNIT (CCU) AND INTERRUPTS

Software by Dr. M. Ohsmann

Since the CCU (compare/capture unit) of the 80C535 is functionally related to interrupts in general, these two subjects are discussed alongside each other in the present course instalment. When used in capture mode, the CCU enables, for instance, accurate time measurements to be performed by software. Similarly, the compare mode may be used to program a generator for variable pulsewidth signals. The timing of the CCU is arranged by Timer 2 in the 80C535. Some of the features of Timer 2 will be discussed here. Only a handful of components, and simple programs, are required to become familiar with the ins and outs of the CCU. As usual, the relevant programs may be found on your course disk.

Some of you may already have noticed that the port bits of Port 1 have a number of additional functions in the

80C535. If one of these port lines is to be used as an input (which includes its use as an interrupt input), the output

The extended interrupt system

To some of you, some interrupts may already be familiar, for instance, those related to Timer 0 and Timer 1, and the external interrupts (P3.2=INT0 and P3.3=INT1). From the 8051/80C32 assembler course, you may also remember that individual interrupt events cause bits in the special function register TCON to be set. Provided the relevant interrupt has been enabled by setting the corresponding bits in the IEN register, an interrupt is then actually generated. In the 80C535, this system has been extended with a couple of interrupt sources. The extended architecture is shown in **Fig. 5**. Special attention should be drawn to the new external interrupts IEX2 to IEX6, which correspond to port bits P1.0 to P1.4 (although differently numbered). As illustrated in **Fig. 6**, the interrupt event then sets the corresponding bit in the IRCON register at address 0C0H. Bits IEX2 to IEX6 are automatically cleared when the interrupt routine is finished. Alternatively, they may be set and reset via software. To be able to enable these interrupts, the relevant bits in the IEN0 or IEN1 register (see **Fig. 7**) must be set. Remember, to be able to enable interrupts at all, the EAL bit (bit 7 in IEN0) must be set.

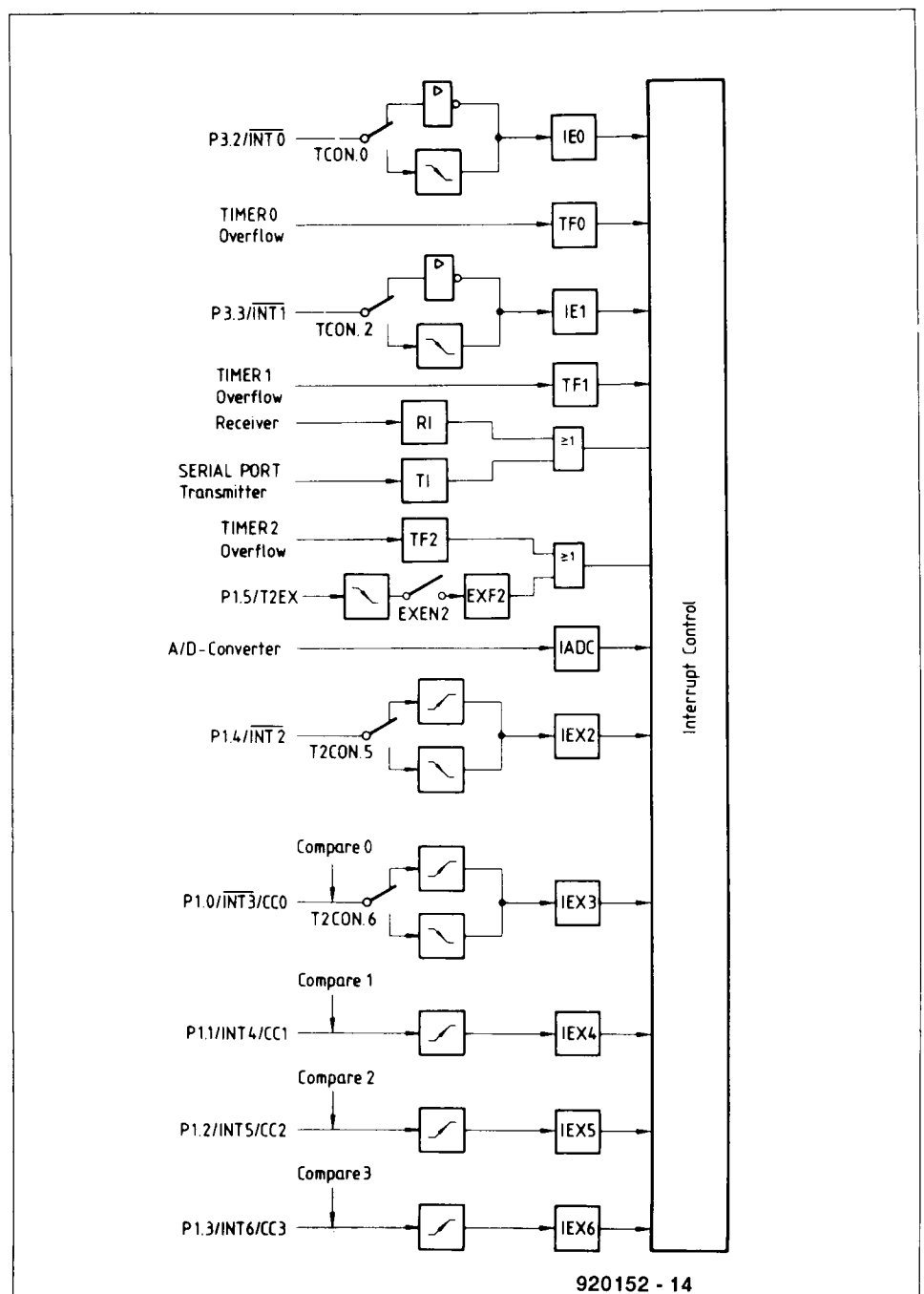


Fig. 5. Schematic showing the interrupt sources which can be used with the 80C535.

Special Function Register IRCON (Address 0C0H)

	0C7H	0C6H	0C5H	0C4H	0C3H	0C2H	0C1H	0C0H	
0C0H	EXF2	TF2	IEX6	IEX5	IEX4	IEX3	IEX2	IADC	IRCON

Bit	Function
IADC	A/D converter interrupt request flag. Set by hardware at the end of a conversion. Must be cleared by software.
IEX2	External interrupt 2 edge flag. Set by hardware when external interrupt edge was detected or when a compare event occurred at pin 1.4/INT2#/CC4. Cleared when interrupt processed.
IEX3	External interrupt 3 edge flag. Set by hardware when external interrupt edge was detected or when a compare event occurred at pin 1.0/INT3#/CC0. Cleared when interrupt processed.
IEX4	External interrupt 4 edge flag. Set by hardware when external interrupt edge was detected or when a compare event occurred at pin 1.1/INT4/CC1. Cleared when interrupt processed.
IEX5	External interrupt 5 edge flag. Set by hardware when external interrupt edge was detected or when a compare event occurred at pin 1.2/INT5/CC2. Cleared when interrupt processed.
IEX6	External interrupt 6 edge flag. Set by hardware when external interrupt edge was detected or when a compare event occurred at pin 1.3/INT6/CC3. Cleared when interrupt processed.
TF2	Timer 2 overflow flag. Set by a timer 2 overflow. Must be cleared by software. If the timer 2 interrupt is enabled, TF2 = 1 will cause an interrupt.
EXF2	Timer 2 external reload flag. Set when a reload is caused by a negative transition on pin T2EX while EXEN2 = 1. When the timer 2 interrupt is enabled, EXF2 = 1 will cause the CPU to vector the timer 2 interrupt routine. Can be used as an additional external interrupt when the reload function is not used. EXF2 must be cleared by software.

920152 - 15

Fig. 6. Interrupts cause certain bits in the IRCON register to be set.

state of the associated pin must be programmed as '1' (logic high). Fortunately, that is the default state after a reset, so no extra programming

is required. However, if the port was previously used as an output, it is recommended to return the relevant pins to 'input' (1) by explicit programming,

80C535 PROGRAMMING

You need the following to be able to follow the 80C535 hardware/assembly course:

Hardware:

- An 80C535 single-board computer as described in *Elektor Electronics* February 1994.
- An IBM PC or compatible with a serial port on COM1: or COM2:.

Software:

- Courseware disk (5.25 inch, 360K MSDOS format).
- EMON52 system EPROM, fitted on 80C535 SBC.

The courseware disk and EPROM are available as a set under order code **6221**. The disk is also available separately under order code 1811. For prices and ordering information, see page 70.

JOIN THE COURSE!

to make absolutely sure that they are inputs after a reset. That is also necessary if you want to use the alternative output functions of these pins, for instance, if pulsewidth modulated signals are generated (see example program 535XMP05.A51 on your disk).

The address vectors for different types of interrupt routine are shown in **Fig. 8**. As with the 80C32, we are faced with a problem: since the monitor EPROM will normally reside at the ad-

Special Function Register IEN0 (Address 0A8H)

	0AFH	0AEH	0ADH	0ACH	0ABH	0AAH	0A9H	0A8H	
0A8H	EAL	W01	ET2	ES0	ET1	EX1	ET0	EX0	IEN0

 This bit is not used for interrupt control.

Bit	Function
EX0	Enables or disables external interrupt 0. If EX0 = 0, external interrupt 0 is disabled.
ET0	Enables or disables the timer 0 overflow interrupt. If ET0 = 0, the timer 0 interrupt is disabled.
EX1	Enables or disables external interrupt 1. If EX1 = 0, external interrupt 1 is disabled.
ET1	Enables or disables the timer 1 overflow interrupt. If ET1 = 0, the timer 1 interrupt is disabled.
ES0	Enables or disables the serial channel 0 interrupt. If ES0 = 0, the serial channel 0 interrupt is disabled.
ET2	Enables or disables the timer 2 overflow or external reload interrupt. If ET2 = 0, the timer 2 interrupt is disabled.
EAL	Enables or disables all interrupts. If EAL = 0, no interrupt will be acknowledged. If EAL = 1, each interrupt source is individually enabled or disabled by setting or clearing its enable bit.

Special Function Register IEN1 (Address 0B8H)

	0BFH	0BEH	0BDH	0BCH	0BBH	0BAH	0B9H	0B8H	
0B8H	EXEN2	W01	EX6	EX5	EX4	EX3	EX2	EADC	IEN1

 This bit is not used for interrupt control.

Bit	Function
EADC	Enables or disables the A/D converter interrupt. If EADC = 0, the A/D converter interrupt is disabled.
EX2	Enables or disables external interrupt 2/capture/compare interrupt 4. If EX2 = 0, external interrupt 2 is disabled.
EX3	Enables or disables external interrupt 3/capture/compare interrupt 0. If EX3 = 0, external interrupt 3 is disabled.
EX4	Enables or disables external interrupt 4/capture/compare interrupt 0. If EX4 = 0, external interrupt 4 is disabled.
EX5	Enables or disables external interrupt 5/capture/compare interrupt 0. If EX5 = 0, external interrupt 5 is disabled.
EX6	Enables or disables external interrupt 6/capture/compare interrupt 0. If EX6 = 0, external interrupt 6 is disabled.
EXEN2	Enables or disables the timer 2 external reload interrupt. EXEN2 = 0 disables the timer 2 external reload interrupt. The external reload function is not affected by EXEN2.

920152 - 29

Fig. 7. Registers IEN0 and IEN1 are used to enable interrupts.

Interrupt request flags	Interrupt vector address	Interrupt source
IE0	0003H	External interrupt 0
TF0	000BH	Timer overflow
IE1	0013H	External interrupt 1
TF1	001BH	Timer 1 overflow
RI0/TI0	0023H	Serial channel 0
TF2/EXF2	002BH	Timer 2 overflow ext. reload
ADAC	0043H	A/D converter
IEX2	004BH	External interrupt 2
IEX3	0053H	External interrupt 3
IEX4	005BH	External interrupt 4
IEX5	0063H	External interrupt 5
IEX6	006BH	External interrupt 6
RI1/TI1	0083H	Serial channel 1
CTF	009BH	Compare timer overflow

920152 - 16

Fig. 8. Overview of fixed interrupt vector addresses.

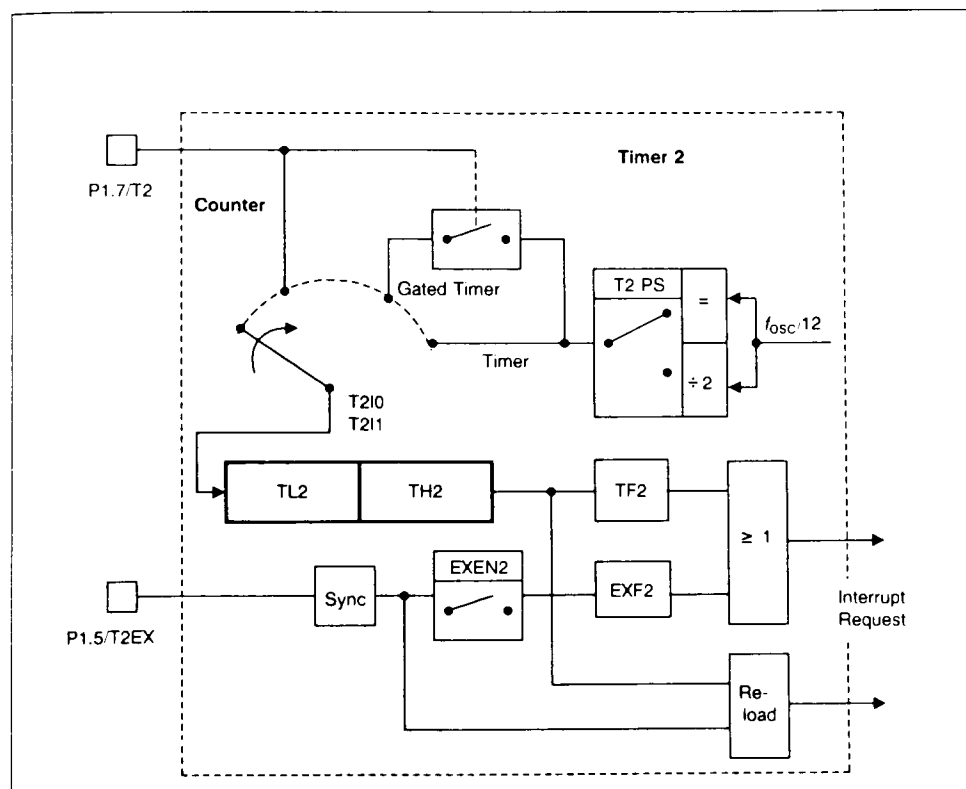


Fig. 9. Input circuit of counter/timer 2.

addresses shown in Fig. 8, the interrupt routines seem out of your control. This problem is solved by the LINK mechanism provided by the EMON51 monitor EPROM, which allows the interrupt routines to be 'chained'.

EMON51 is capable of setting up links for 8031/8051 and 80C32 inter-

rupts only. By contrast, the new monitor, EMON52, handles all 80C535 interrupts also. Consequently, you must use EMON52 instead of EMON51 if you want to use the monitor to assist with programming interrupts which are specific to the 80C535. Since it was desired to enable readers in possession of

the 'old' monitor EPROM to follow the present course without problems, there are no example programs on the course disk that make use of the extended interrupts offered by the 80C535. Nonetheless, some know-how on interrupts will be required to fully understand the operation of Timer 2 (fortunately, a corresponding interrupt was already foreseen in the 'old' monitor, EMON51).

Owing to lack of space, the interrupt priority assignment used in the 80C535 is not discussed in this course. Details on this subject may be found in the Siemens/Intel datasheets.

Timer 2: the CCU core

Before we run into a lot of confusion, it should be made clear that the 8052 and 8032 microcontrollers also sport a 'Timer 2'. Timer 2 in the 80C535, however, works in a totally different way, because it is controlled by other bits in other SFRs. The 80C535 is, therefore, not compatible with the 8052 in this respect. It is, however, compatible with the 8051, simply because the latter does not have a Timer 2.

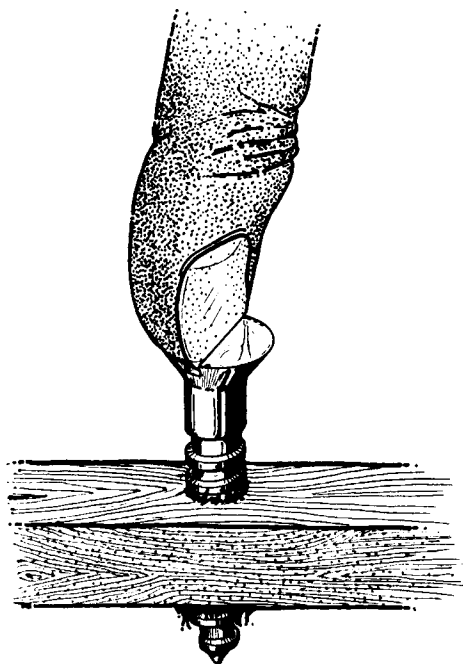
For now, let us concentrate on Timer 2 in the 80C535. This is a 16-bit timer consisting of SFRs TL2 (address 0CCH, LS counter byte) and TH2 (address 0CDH, MS counter byte). The clock signal for Timer 2 can be derived from different signals. The input circuit is shown in Fig. 9. Figure 10 shows the configuration of the timer in 're-load' mode, while Fig. 11 lists the function of the bits in the T2CON special function register (at address 0C8H), which serves to control Timer 2. As can be deduced from Fig. 9, the timer clock signal can be generated in four ways. The selection is made by programming bits 1 (T2I1) and 0 (T2I0) in register T2CON.

1. If both bits are at 0, the counter (timer) stops, since it is no longer supplied with a clock signal.

2 The bit combination '01' selects the so-called timer function, when the internal clock is used to clock the counter. The internal clock is the quartz crystal frequency divided by 12. Since a 12-MHz quartz crystal is used, the internal clock is a 1-MHz signal, but only if the available divide-by-two prescaler is switched off (bit 7=T2PS=0 in T2CON). If the prescaler is switched on (by setting the T2PS bit), the internal clock frequency is lowered to 500 kHz.

3. If bits T2I1 and T2I0 are given the value '10', the so-called counter function is selected, when the signal applied to the P1.7/T2 pin is used as a clock. That allows Timer 2 to be used to count external events. The counter

8051 Programming?



If you've tried this, you'll know what it's like using 8051 assembler.

Admittedly, given enough time and effort, even the impossible can be accomplished.

But can your project afford to wait?

Keil C51 is *very* simple to use and yet yields the fastest and smallest code of any 8051 C compiler. With direct access to the 8051 cpu at a bit/register level in C, assembler programmers feel instantly at home.

C51 Professional Developer's Kit Comprises:

- * Full ANSI C implementation for the 8051 family
- * Near-assembler code efficiency
- * Function-level optimisation
- * Extensions for 80C517/80C751
- * Small/Compact/Large/Banked memory support
- * **DScope51+** cpu simulator/debugger
- * **A51** macro assembler
- * 8051 Real Time Executive
- * Support from official **C51 User Group**
- * Free 8051 C Programmer's Handbook

To see how **C51** takes the pain out of 8051 programming, call now for our comprehensive information pack including demonstration versions of the compiler and debugger.

Hitex (UK) Ltd
Warwick University
Science Park
Coventry, CV4 7EZ

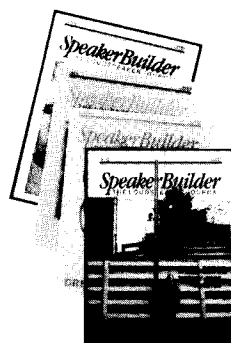
hitex



☎ 0203 692066, FAX 0203 692131

Use your electronics know-how to create great sound!

Speaker Builder, the world's only loudspeaker magazine in English, can show you how to achieve excellence in sound from your stereo system. Whether you're modifying and improving your present speakers or building a new design from scratch, **Speaker Builder** contains the latest in loudspeaker technology. Within its pages, learn about Thiele-Small design software, build an inexpensive measurement mike good enough for the professionals, or simply indulge in reading about the experiences of others using their technical skills to improve the sound around them.



Since 1980, **Speaker Builder** has been exploring both the traditional and more unusual formats for loudspeakers. From pipes to corrugated boxes to transmission lines and electrostatics, every conceivable medium is discussed. An international forum for speaker enthusiasts the world over, sharing ideas and designs, **Speaker Builder** has made it possible for thousands to enjoy the highest quality sound without straining their budgets.

The publishers of **Speaker Builder** invite you to use your electronics know-how to discover the world of better sound. To subscribe, simply return the form below with your payment or FAX your credit card order and receive 8 issues of **Speaker Builder** for a low introductory rate of \$45 for a one-year subscription. That's a \$5 savings off the regular overseas airmailed rate. Or you may subscribe for two years at \$80 (\$10 off).

☐ One Year \$45 ☐ 2 Years \$80

Remittances in US funds drawn on a US bank only.

MCVISA NUMBER

EXP. DATE

NAME

ADDRESS

CITY

ST

ZIP

Speaker Builder

PO Box 494, Peterborough, NH 03458-0494 USA
(603)924-9464 or FAX (603)924-9467 24 hours



IF AN ADVERT IS IN PRINT, IS IT PROPER?

Most advertisements are perfectly proper.

A few are not.

The Advertising Standards Authority not only monitors over 850 advertisements every month, it ensures compliance with the rules in the strict Code of Advertising Practice.

So when you question an advertiser, they have to answer to us.

To find out more about the role of the ASA, please write to the address below.

Advertising Standards Authority,
Department X, Brook House, Torrington
Place, London WC1E 7HN.



This space is donated in the interests of high standards in advertisements.

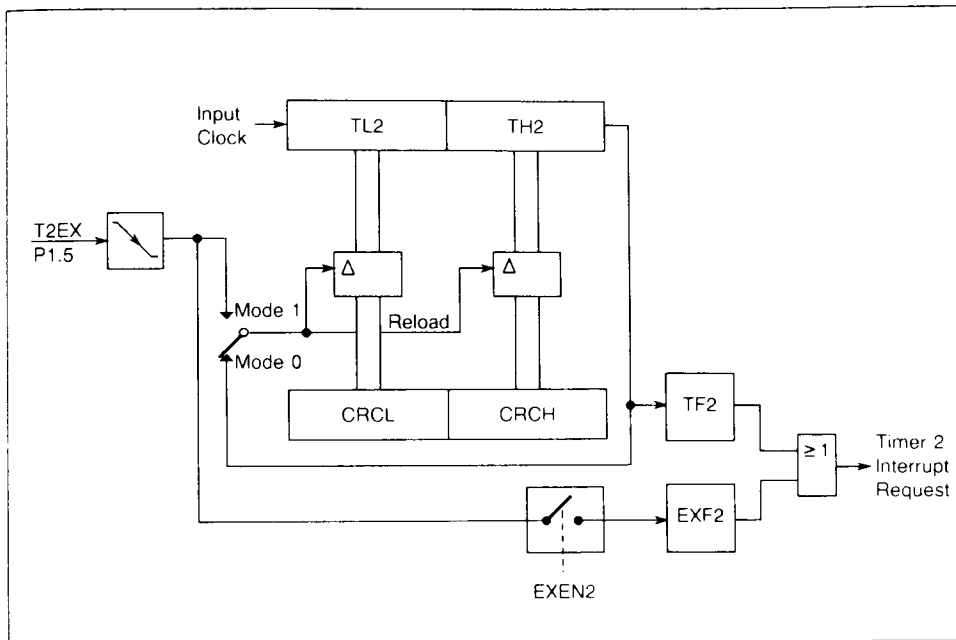


Fig. 10. Timer 2 in reload mode.

Special Function Register T2CON

	0CFH	0CEH	0CDH	0CCH	0CBH	0CAH	0C9H	0C8H	
0C8H	T2PS	0FFH	0FFH	T2R1	T2R0	T2CM	T2I1	T2I0	T2CON
	These bits are not used in controlling the CCU.								

Timer 2 control register. Bit-addressable register which controls timer 2 function and compare mode of registers CRC, CC1 to CC3.

Bit	Function
T2I1	T2I0
0	0
0	1
1	0
1	1
T2R1	T2R0
0	X
1	0
1	1
T2CM	
T2PS	

920152 - 19

Fig. 11. The functions of Timer 2 are controlled via bits in the T2CON register.

is clocked on the negative-going (falling) edge of the external signal. It should be noted, however, that the logic state of pin P1.7 is detected only once during every machine cycle. Consequently, the maximum count rate equals 500 kHz. Also, the 'low' and 'high' times of the input signal must have a minimum length of one machine cycle, to enable a signal edge to

be detected. Remember, a machine cycle equals 12 times the quartz cycle time, i.e., one microsecond at the quartz frequency used on the 80C535 SBC.

4. If T2I1 and T2I0 are both at '1', Timer 2 is programmed to function as a 'gated timer'. In this mode, too, the internal clock (with or without the T2PS prescaler) is used to clock the timer.

However, the clock signal only reaches the counter if P1.7 is at '1'. This mode may be used, for instance, to determine the pulse/pause ratio of signals. That also concludes the discussion of the different types of signal that may be used to clock Timer 2. The T2CM bit (bit 2 in T2CON) is skipped for the moment, and we turn our attention to bits 3 and 4 in T2CON.

Timer 2 reload

A number of programming options are available to determine the program flow when Timer 2 overflows at its maximum counter state, 0FFFFH, or 65535. In any case, this event causes the TF2 bit (bit 6 in the IRCON, see Fig. 6) to be set. What happens next is determined by the state of bit 4 (T2R1) and bit 3 (T2R0), which are both in the T2CON SFR. If T2R1 is at '0', the so-called reload mode is disabled, and the counter simply starts at 0 again. If T2R1 is at '1', Timer 2 is operated in reload mode, in which bit T2R0 determines when the counter is reloaded with the value contained in the reload register pair CRCL-CRCH (compare Fig. 10). In mode 0 (T2R0 = 0), the counter is loaded after the overflow. The reload value is then contained in the CRCL (LS byte; 0CAH) and CRCH (MS byte; 0CBH) register pair. If the pair contains, for example, the value 0FFFCH (-4), the counter counts 0FFFCH, 0FFFDH, 0FFFEH, 0FFFFH, 0FFFCH, and so on. If the T2R1 bit is at '1', the counter is reloaded any time a negative pulse edge is detected at pin P1.5. This option is particularly useful if you want to synchronize the counter with an external signal. For instance, a phase control circuit may be realized by driving pin P1.5 with a 50-Hz signal derived from the mains. This effectively synchronizes Timer 2 with the mains frequency. At a count rate of 1 MHz (internal clock used without the prescaler), that enables a phase control circuit with a resolution of one microsecond to be realized.

If bit EXEN2 (bit 7 in the IEN1 register, see Fig. 7) is set, each reload signal edge at P1.5 also causes bit EXF2 (bit 7 in IRCON, see Fig. 6) to be set. This can be interrogated by software, while an interrupt may also be generated by enabling the relevant interrupt.

Next time: in next month's final instalment of the course we will conclude the discussion of the CCU and the Timer 2 operation using a couple of programming examples.

'STAMP' BASIC COMPUTER

It's small, easy to program, flown in from the States, affordable, based on a RISC processor, and a real block buster when it comes to developing turnkey software in less time than you ever dreamed possible. It's the wonderful stamp-sized computer that runs BASIC. Real cute!

At first glance, the Stamp may seem fairly minimal — and in fact, it is, hence its name. But, with software that fully utilizes all available hardware, the Stamp gives you useful and powerful features — without the cost of hardware.

The Stamp has a size of about 5×2.5 cm (2×1 in.), and consists of two main components. The brain of the Stamp is a PIC16C56 microcontroller¹ running the PBASIC interpreter developed by Parallax Inc. A 256-byte EEPROM holds a tokenized version of your BASIC program, which is read and executed by the interpreter contained in the PIC. The remainder of the Stamp is taken up by a 4-MHz resonator, a 5-V regulator, and a 9-V PP3 battery clip. Also included is a small prototyping area, which provides connection points



Sources: Parallax Inc. and K.H. Eichler (Wilke Technology).

for the Stamp's eight I/O lines, 5-V supply, unregulated supply, and ground.

The BASIC Stamp is programmed in the simple BASIC language. The language includes familiar instructions such as FOR...NEXT, IF...THEN, and GOTO, as well as SBC-specific instructions such as SERIN (serial input) and BUTTON (button input). Each instruction takes two or three bytes of EEPROM space, resulting in a maximum program size of 80 to 100 instructions. As for execution speed, programs run at the rate of about 2,000 instructions per second.

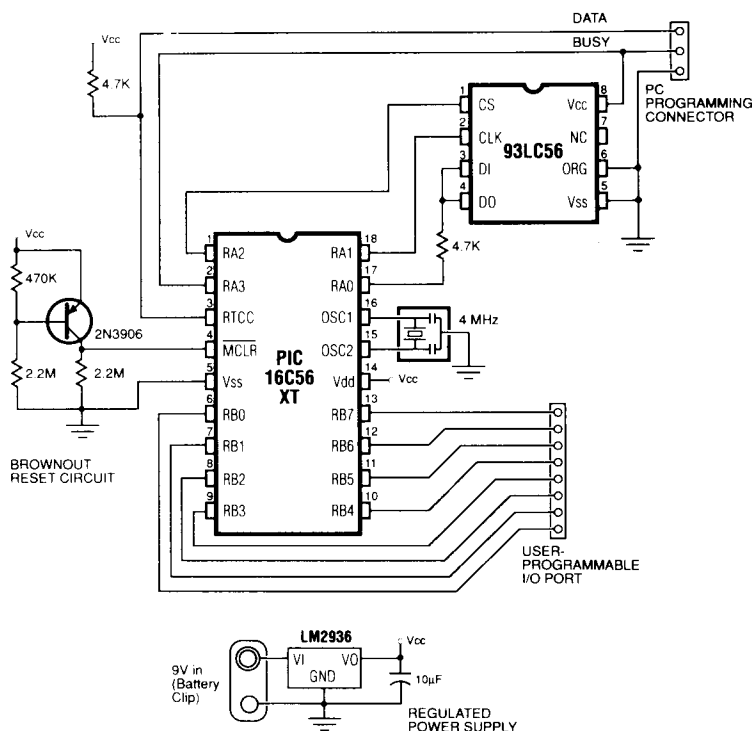
To write programs for the Stamp, you will need a Development Kit. The kit includes editor software for a PC, a cable to connect the Stamp to the PC, one BASIC Stamp, and a manual. By connecting the Stamp to your PC's parallel port and then running the editor, you can write BASIC programs and then download them to the Stamp. If you are familiar with the BASIC language, it is a matter of minutes before you have your first program running. Furthermore, a number of application notes are available free of charge from Parallax Inc. to help you become acquainted with programming the computer.

It is possible to use the BASIC interpreter developed by Parallax Inc. in your own designs. This can be achieved by purchasing 'bare' interpreter chips from Parallax Inc. at prices ranging from \$5 (1,000 off) to \$18 (one off). Add to that a 256-EEPROM, a 4-MHz resonator and a power supply, and you can start using your own miniature BASIC computer. Applications? What about an LCD user-interface terminal, interfacing an A-D converter, a matrix keypad in/LCD screen out circuit, a servo motor driver, a pulse meter, a morse code generator, an intelligent battery charger, or a serial stepper motor controller? The list can be extended to any length, depending only on your creativity.

Circuit description

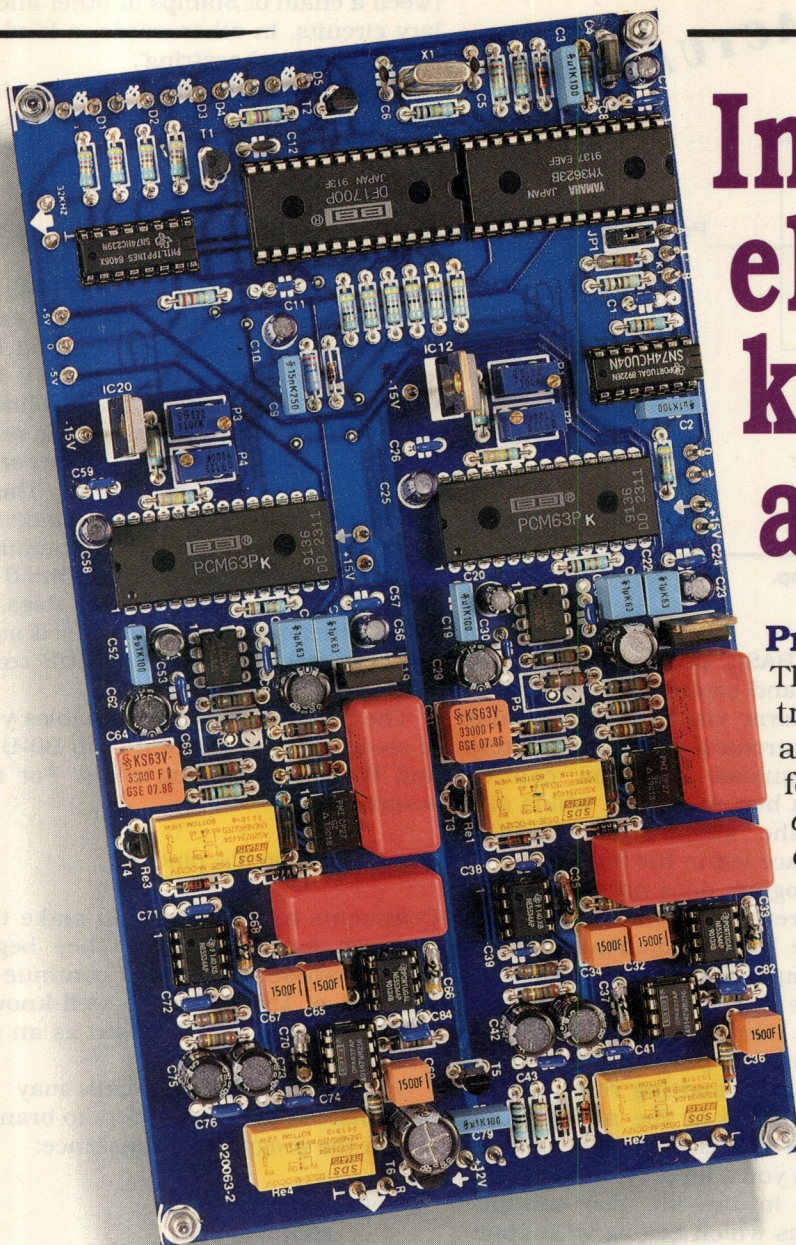
Figure 1 shows the circuit diagram of the Stamp board supplied by Parallax Inc. as part of their Development Kit. The component count is, well, low! The component locations on the board are shown in **Fig. 2**.

The microcontroller used is a PIC16C56XT preloaded with Parallax's PBASIC interpreter. The PIC device also contains an I/O port, a serial interface and a clock oscillator. The program memory is formed by a 93LC56



940032 - 11

Fig. 1. Schematic of the Stamp single-board BASIC computer.



Increase your electronics know-how and skills

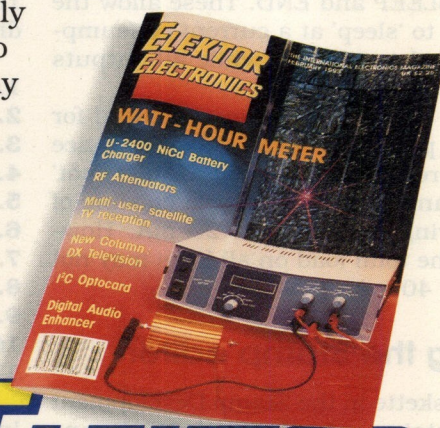
Practical creativity in electronics

The speed and intensity with which electronics penetrates our daily lives at home, at work, or in our car, tends to make us forget that we can use *electronics creatively* by building designs with a practical application and having the satisfaction of a successfully finished project. *Elektor Electronics*, which is distributed all over the world, can help you achieve these goals. Throughout the year, the magazine features original construction projects, informative articles and news on the gamut of electronics, science & technology, book reviews and information on new products.

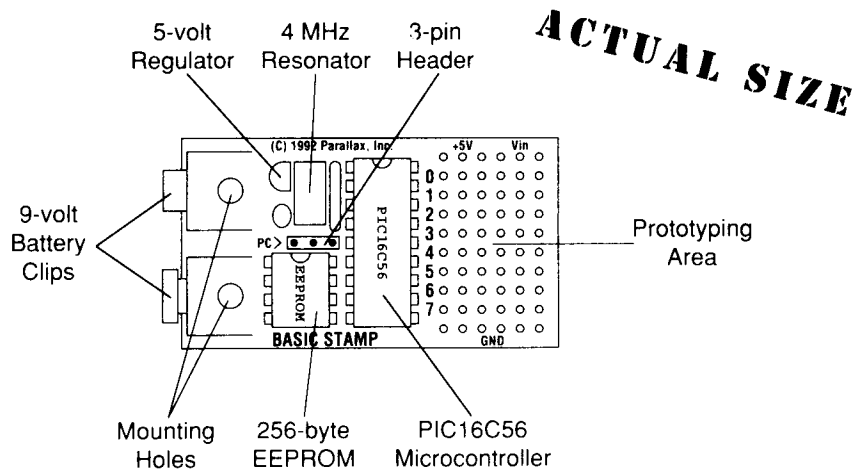
The value of an annual subscription

If you wish to increase your electronics know-how and skills, take out an annual subscription to *Elektor Electronics* by filling in the order form on page 71 or writing or telephoning to the address below. You will then not only have the convenience of having the magazine delivered to your home and the peace of mind that you will not miss any issue, but you will also save money compared with buying the magazine from a bookstall: the price of a subscription in Britain for the 11 annually published issues is the same as the average price of 10 issues bought from a bookstall. Rates are shown on page 72.

World Wide Subscription Service Ltd,
Unit 4, Gibbs Reed Farm,
Pashley Road, TICEHURST,
East Sussex TN5 7HE, England
Telephone (0580) 200 657 (National)
or +44 580 200 657 (International)
Fax (0580) 200 616 (National)
or +44 580 200 616 (International)



ELEKTOR ELECTRONICS



940032 - 16

Fig. 2. Locations of the main components on the BASIC Stamp.

EEPROM which retains the BASIC program even in the absence of the supply voltage. The EEPROM has a storage capacity of 256 bytes, allowing a program of between 80 and 100 lines of BASIC to be stored.

An on-board low-drop 5-V voltage regulator allows the Stamp to be powered from any d.c source with an output voltage between 6 V and about 15 V. In most cases, a 9-V PP3 size battery will be used to power the Stamp.

The schematic shows a power-down circuit based on one transistor and three resistors. Apart from ensuring a good reset no matter how long the Stamp has been off, the reset circuit also clears the PIC microcontroller after a 'brown-out'. A brown-out occurs when the supply voltage drops below 5 V, but not low enough to allow the chip's reset function to operate.

The Stamp offers a clever energy-saving power-down scheme which is controlled by three BASIC instructions: NAP, SLEEP and END. These allow the Stamp to 'sleep' at a current consumption of about 20 μ A, while all outputs retain their logic level.

The eight I/O lines may be used for many purposes, even for resistance measurement using the BASIC 'pot' command. Each I/O line is capable of supplying up to about 20 mA. However, the total load on all lines may not exceed 40 mA.

Using the Stamp editor

The diskette in the Stamp Development Kit contains a simple editor which runs on a DOS PC. The editor offers the following functions: Run, Load, Save and Quit. Once you have the editor running, the screen is available to write your BASIC program. If you are ready to test it, download the program to the Stamp using the ALT-R (Run) com-

mand. The BASIC program is compiled by the PC, and copied to the Stamp in tokenized form via the PC's parallel printer (Centronics) port. The progress of the download operation can be viewed as a horizontal bar, which also indicates the amount of EEPROM memory space left in the Stamp.

If the program does not function as expected, return to the editor, and change the BASIC commands as required. Simple word processing commands like cursor movement, copy, cut, paste and search/replace are available for that purpose. The syntax and program formatting rules are explained in detail in the manual that comes with the Stamp Development Kit. To save you a lot of typing, the program disk in the kit also contains 14 programs which belong with application notes published for the Stamp.

PBASIC command set

The PBASIC command set can be subdivided into eleven groups:

1. Branching
2. Looping
3. Numerics
4. Digital in/out
5. Serial in/out
6. Analogue in/out
7. Sound
8. EEPROM access
9. Time
10. Power control
11. Program debugging

In addition to the commands available most BASIC dialects, there are a number of Stamp-specific commands which allow, for instance, an external circuit to generate analogue voltages, or measure resistance values. Additionally, there are commands to generate tones, and to set up serial communication be-

tween a chain of Stamps or other ancillary circuits, in other words, a kind of network 'on a shoestring'.

As regards variables used in the BASIC programs, the following should be observed:

- » the variables area is limited to 16 bytes;
- » of these, two bytes are required for the I/O lines;
- » the remaining 14 bytes may be used as word variables (W0-W6) and byte variables (B0-B13). Of these, B0 and B1 (W0) may be used as bit variables 0-15. Of the two bytes used for the I/O lines, the first indicates the state of the relevant line (high or low), and the second, the direction (input or output). There are several ways of addressing individual lines, for instance, by programming Port.0, Pins.0 or Pin0, Port.8, Dirs.0 or Dir0. With the rest of the variables, it should be noted that W6 is used as a software stack whenever GOSUB commands are executed.

The SYMBOL command enables you to assign names different from B0-B13 and W0-W6 to the variables. For instance:

symbol switch = pin0

Comments can be added to make the program more readable. They begin with an apostrophe (') and continue to the end of the line. The well-known REM command may be used as an alternative.

Very conveniently, labels may be used instead of line numbers to branch within the program. For instance:

```
loop: toggle pin0
      goto loop
```

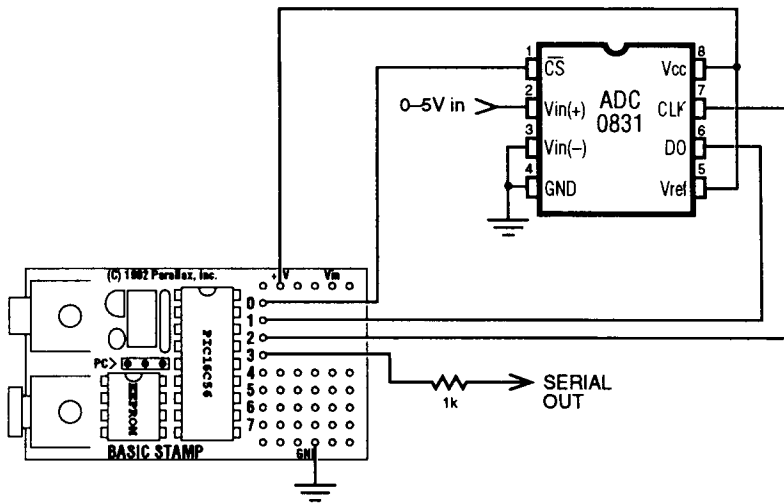
Finally, as regards general formats, the editor is case sensitive, except when processing strings (such as "stamp"). Multiple instructions and labels can be combined on the same line by separating them with colons (:). For instance,

```
dirs = 255 : for b2 = 0 to 100 : pins =
b2 : next
```

An example application

The following application note, originally published by Parallax, Inc. as no. 2, presents the hardware and software required to interface an 8-bit serial analogue-to-digital converter to the Parallax BASIC Stamp. The application schematic is shown in Fig. 3.

The BASIC Stamp's instruction 'pot' performs a limited sort of analogue-to-digital conversion. It lets you interface nearly any kind of resistive sensor to the Stamp with a minimum of difficulty. However, many applications call for a true voltage-mode analogue-to-



940032 - 17

Fig. 3. Circuit to accompany AD_CONV.BAS.

```

' PROGRAM: ad_conv.bas
' BASIC Stamp program that uses the National ADC0831 to acquire analog data and output
' it via RS-232.

Symbol CS      = 0
Symbol AD      = pin1
Symbol CLK     = 2
Symbol S_out   = 3
Symbol data    = b0
Symbol i       = b2

setup:  let pins = 255          ' Pins high (deselect ADC).
        let dirs = %11111101  ' S_out, CLK, CS outputs; AD input.

loop:   gosub conv             ' Get the data.
        serout S_out,N2400,(&b0,13,10) ' Send data followed by a return and linefeed.
        pause 2000             ' Wait 2 seconds
        goto loop              ' Do it forever.

conv:   low CLK                ' Put clock line in starting state.
        low CS                 ' Select ADC.
        pulsout CLK, 1         ' 10 us clock pulse.
        let data = 0           ' Clear data.
        for i = 1 to 8         ' Eight data bits.
            let data = data * 2 ' Perform shift left.
            pulsout CLK, 1     ' 10 us clock pulse.
            let data = data + AD ' Put bit in LSB of data.
        next i                 ' Do it again.
        high CS                ' Deselect ADC when done.
        return

```

940032 - 18

Fig. 4. Listing of AD_CONV.BAS.

digital converter (ADC). One that is particularly suited to interfacing with the Stamp is National Semiconductor's ADC0831.

Interfacing the ADC0831 requires only three input/output lines, and of these, two can be multiplexed with other functions (or additional ADC0831s). Only the chip-select (CS) pin requires a dedicated line. The ADC's range of input voltages is controlled by the V_{REF} and $V_{IN(-)}$ pins. V_{REF} sets the voltage at which the ADC will return a full-scale output of 255, while $V_{IN(-)}$ sets the voltage that will return 0.

In the example application, $V_{IN(-)}$ is

at ground, and V_{REF} is at +5 V; however, these values can be as close together as 1 V without harming the device's accuracy or linearity. You may use diode voltage references or trim pots to set these values.

The sample program is listed in Fig. 4. It reads the voltage at the ADC's input pin every two seconds, and reports it to the PC via a 2400-baud serial connection. The subroutine 'conv' handles the details of getting data out of the ADC. It enables the ADC by pulling the CS line low, then pulses the clock (CLK) line to signal the beginning of a conversion. The program then en-

ters a loop in which it pulses CLK, gets the bit on pin AD, adds it to the received byte, and shifts the bits of the received byte to the left. Since BASIC traditionally does not include bit shift operations, the program multiplies the byte by two to perform the shift.

When all bits have been shifted into the byte, the program turns off the ADC by returning CS high. The subroutine returns with the conversion result in the variable 'data'. The whole process takes about 20 milliseconds.

You can add more ADC0831s to the circuit as follows: connect each additional ADC to the same clock and data lines, but assign it a separate CS pin. Modify the 'conv' subroutine to take the appropriate CS pin low when it needs to acquire data from a particular ADC. That's it!

The program may be downloaded from the Parallax Bulletin Board system in the USA under the file name AD_CONV.BAS. You can reach the BBS at (+1) 916 624-7101.

Who, what, where?

In addition to the BASIC Stamp Development Kit sold by Parallax Inc., Wilke Technology of Germany supply a range of products, including a compiler, an extensive hardware development system, and different types of Stamp SBC. It should be noted that these products are aimed mainly at advanced users, which is reflected by the cost. The hardware development system marketed by Wilke Technology is much more elaborate than the Development Kit supplied by Parallax.

To request information, prices, or order Stamp-related products, contact

Parallax Inc., 3805 Atherton Road, #102, Rocklin, CA 95765, U.S.A. Tel. (+1) 916 624-8333. Fax: (+1) 624-8003. BBS: (+1) 916 624-7107 (300-14,400 bps; no parity; 8 data bits; 1 stop bit).

Wilke Technology products are available from

Wilke Technology, Postfach 1727, Krefelder Str. 147, D-5100 Aachen, Germany. Tel. (+49) 241 154071. Fax: (+49) 241 158475.

In Hungary, contact

Humansoft, Ltd., H-1149 Budapest, Angol u. 24/b, Hungary. Tel. (+36) 1163 2879, fax: (+36) 1251 3673.

Further distributor information may be obtained from Parallax Inc.

Note:

1. See also 'PIC programmer' in the March 1994 issue of *Elektor Electronics*.

FIGURING IT OUT

PART 16 – MORE ABOUT FOURIER

By Owen Bishop

This series is intended to help you with the quantitative aspects of electronic design: predicting currents, voltage, waveforms, and other aspects of the behaviour of circuits.

Our aim is to provide more than just a collection of rule-of-thumb formulas.

We will explain the underlying electronic theory and, whenever appropriate, render some insights into the mathematics involved.

Last month we described how the Fourier series is used to represent any periodic waveform. To recapitulate, the series consists of:

constant (d.c.) term
+
cosine terms
+
sine terms.

The constant term and the coefficients of the cosine and sine terms are found by integration:

$$A_0 = \frac{1}{2\pi} \int_0^{2\pi} y dt \quad [\text{Eq. 123}]$$

$$a_n = \frac{1}{\pi} \int_0^{2\pi} y \cos nt dt \quad [\text{Eq. 124}]$$

$$b_n = \frac{1}{\pi} \int_0^{2\pi} y \sin nt dt \quad [\text{Eq. 125}]$$

The constant term, which equals the average value of the variable (for example, voltage) during one cycle, can sometimes be found by geometrical means. We are often able to simplify the integrations by using the standard integrals given in Box 2 of Part 15. A frequent result of simplification is that the series for a given waveform has no cosine terms or no sine terms. Now we will look at some further ways of simplifying the calculations.

Even functions

An even function is one which is symmetrical about the y-axis. It is as if the y-axis acts as a mirror, reflecting the curve of the waveform for positive values of x on to the negative side of the axis. **Figure 131** shows some examples of even functions.

Mathematically, we can express this by:

$$f(x) = f(-x).$$

If a waveform is an even function, we can say, without any need for integrations, that:

- it may or may not have a con-

stant term;

- it has cosine terms;
- it has no sine terms.

An obvious example of an even function is the cosine waveform of **Fig. 131a**, which has a cosine term and no sine terms. Whether or not it has a constant term depends on whether it is superim-

posed on a constant d.c. level (as, for example, is the waveform of **Fig. 131b**). If you find that a waveform is symmetrical about the y-axis, you need not waste time by trying to evaluate the integral of Eq. 125.

Odd functions

These are symmetrical about the origin. If we imagine the curve spun round through 180° around a centre located at the origin, it comes to lie on itself.

Figure 132 shows some odd functions. The characteristic features of an odd function are:

- it has no constant term;
- it has no cosine terms;
- it has sine terms.

In short, an odd function has only sine terms. Since it is symmetrical about the origin, it can never have a constant term. Between them, even and odd functions cover most of the waveforms we are likely to meet in electronics, but there are a few other recognizable types of waveform that yield series with distinctive features. The next two headings deal with these.

Half-wave inversion

In **Fig. 133**, the waveform between $t = 0$ and $t = \pi$ is repeated, but inverted, between $t = \pi$ and $t = 2\pi$. This is known as **half-wave inversion**. The Fourier series for such a waveform has

- no constant term;
- no even cosine terms;
- no even sine terms.

The effects of half-wave inversion and the kinds of symmetry are cumulative. The waveform of **Fig. 133a** has odd symmetry and half-wave inversion. Because it has odd symmetry (and also because it has half-

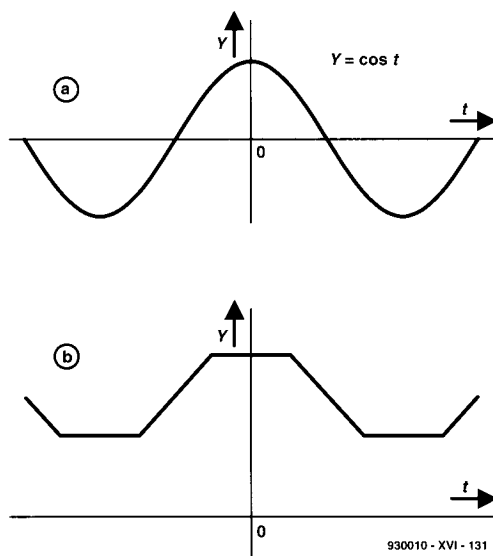


Fig. 131

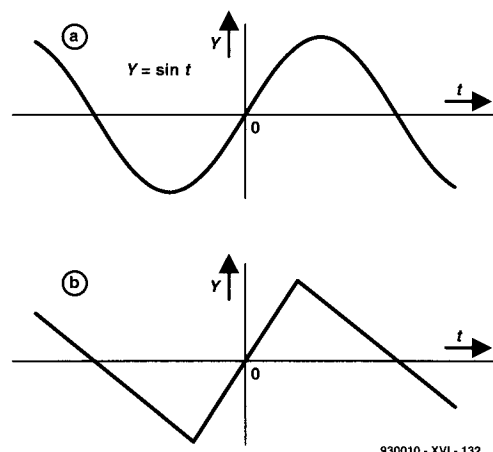


Fig. 132

wave inversion), it has no constant term. Because it has odd symmetry, it has no cosine terms. Because it has half-wave symmetry, it has no even sine terms. We are left with a series that has only odd sine terms. By contrast, the waveform of **Fig. 133b** has even symmetry and half-wave inversion. It therefore has no constant term and no sine terms. It has only odd cosine terms.

Half-wave repetition

The waveform of **Fig. 134** is repeated in the second half of the cycle. For such a waveform, the series has:

- possibly a constant term;
- no odd cosine terms;
- no odd sine terms.

The example here has a constant term. Removing the constant term of this example would shift the curve down, giving it odd symmetry. It therefore has only even sine terms. This rule does not necessarily eliminate the need to calculate all three of A_0 , a_n , and b_n , but does at least provide a check that your calculations are correct.

Square waves

The waveforms we have analysed so far have all been continuous within the period 0 to 2π . Now we will tackle a waveform that has an abrupt change of level during the cycle. **Figure 135** is a square wave with a mark:space ratio of 1. We have arbitrarily taken the 'high' level to be 3. This is a piecewise function and, to find the series, we have to deal with each part of the function separately. First of all, the constant term is the sum of two integrals:

$$A_0 = \frac{1}{2\pi} \int_0^\pi 3 dt + \frac{1}{2\pi} \int_\pi^{2\pi} 0 dt$$

In this example, the second integral has zero value:

$$\begin{aligned} A_0 &= \frac{1}{2\pi} [3t]_0^\pi + 0 \\ &= \frac{3}{2\pi} [\pi - 0] = 1.5 \end{aligned}$$

This result could have more readily been obtained by inspecting the graph and noting that the average value of y is 1.5.

For the value of a_n we again integrate for both parts of the waveform:

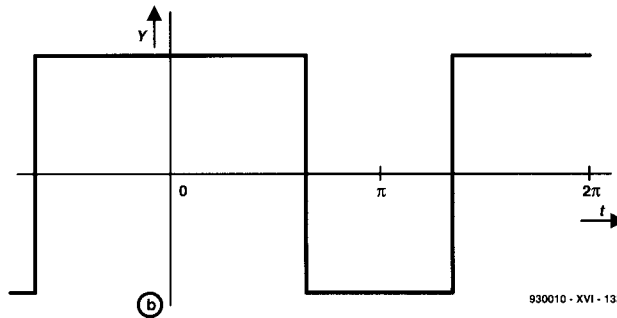
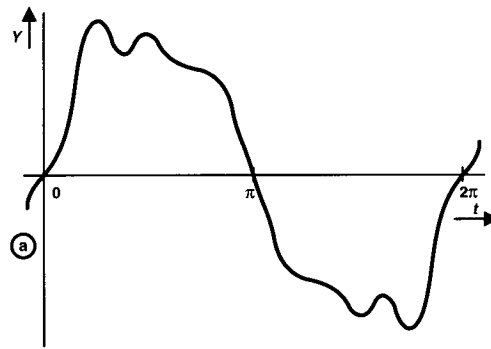


Fig. 133

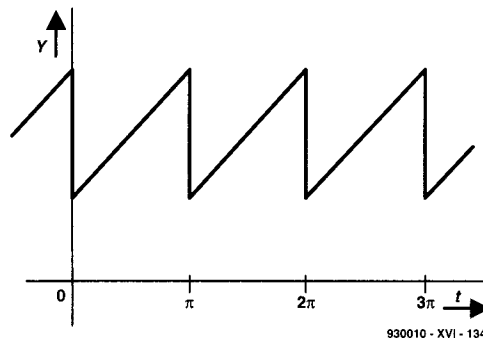


Fig. 134

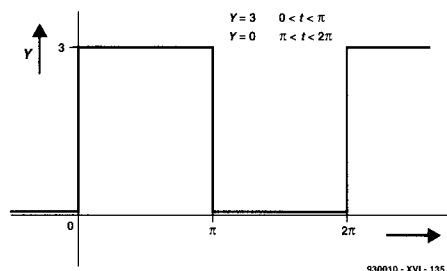


Fig. 135

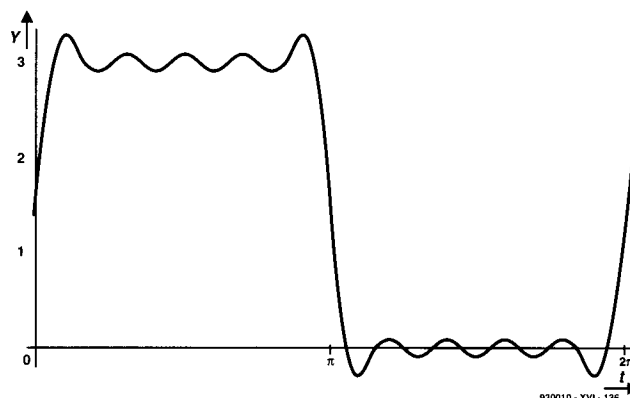


Fig. 136

$$\begin{aligned} a_n &= \frac{1}{\pi} \int_0^\pi 3 \cos nt \, dt + 0 \\ &= \frac{3}{n\pi} [\sin nt]_0^\pi \\ &= \frac{3}{n\pi} [\sin n\pi] = 0.9549 \frac{\sin n\pi}{n} \end{aligned}$$

But $\sin n\pi = 0$ if n is an integer, making $a_n = 0$. This result means that there are no cosine terms. We could have told this at the start because this is essentially an odd function, raised on a d.c. level of 1.5 (compare with **Fig. 134**). The constant term 1.5 simply raises it above the x-axis. If the constant term is ignored, so that, in effect, it is lowered until it passes through the origin, it becomes an odd function and has only sine terms.

Finally, we calculate b_n :

$$\begin{aligned} b_n &= \frac{1}{\pi} \int_0^\pi 3 \sin nt \, dt + 0 \\ &= \frac{-3}{n\pi} [\cos nt]_0^\pi \\ &= \frac{-3}{n\pi} [\cos n\pi - \cos 0] \\ &= \frac{-3}{n\pi} [\cos n\pi - 1] \end{aligned}$$

There are two possibilities to be considered:

- when n is even, $\cos n\pi = 1$, which makes $b_n = 0$;
- when n is odd, $\cos n\pi = -1$, in which event $b_n = 6/n\pi = 1.9099/n$.

The series has only odd cosine terms. This, too, might have been foreseen: when the waveform is shifted down to be symmetrical about the x-axis, it has half-wave inversion, resulting in it having no even terms. Writing out the series:

$$\begin{aligned} y &= 1.5 + 1.9099 \left(\sin t + \frac{\sin 3t}{3} + \right. \\ &\quad \left. + \frac{\sin 5t}{5} + \frac{\sin 7t}{7} + \frac{\sin 9t}{9} + \dots \right) \end{aligned}$$

Figure 136 shows the graph of the series when taken to the 10th harmonic ($n = 9$).

Frequency spectrum

Another way of looking at a series is to plot its frequency spectrum. This has a vertical line for each frequency, the height of the line being proportional to the amplitude of the frequency. In the series we have just calculated, the amplitude of the fundamental is 1.9099. The amplitude of the 1st harmonic is $1.9099/3 = 0.6366$. **Figure 137** shows the plot of the fundamental

and first 10 harmonics. The even ones are missing and the amplitude of the odd ones falls away fairly rapidly. Last month we analysed a sawtooth wave before and after passing it through a high-pass filter. **Figure 138** shows the frequency spectra of these waveforms; the effect of filtering is obvious.

Pulse waveforms

In **Fig. 139** we have a pulse waveform, which is another example of a piecewise function. This is analysed in a similar way to the 1:1 square wave above. If we shift it $\pi/10$ to the left, the pulse begins at $-\pi/10$ and ends at $\pi/10$. It is now an even function, so its Fourier series has no sine terms. By inspection, we can tell that $A_0 = 0.3$.

For the cosine terms:

$$\begin{aligned} a_n &= \frac{1}{\pi} \int_{-\pi/10}^{\pi/10} 3 \cos nt \, dt \\ &= \frac{1}{\pi} \left[\frac{3}{n} \sin nt \right]_{-\pi/10}^{\pi/10} \\ &= \frac{3}{n\pi} \left[\sin \frac{n\pi}{10} - \sin \frac{-n\pi}{10} \right] \\ &= \frac{6}{n\pi} \sin \frac{n\pi}{10} \\ &= 1.9099 \sin \frac{(n\pi/10)}{n} \end{aligned}$$

If $n = 1$, then $\sin(n\pi/10) = 0.3090$; for $n = 2$ to 9, we obtain 0.5878, 0.8090, and so on to 0.3090. When $n = 10$, $\sin(n\pi/10) = 0$, so there is no 9th harmonic. The sequence of values is repeated for $n = 11$ to 20, except that they are negative. From $n = 21$ onwards the whole sequence repeats, but we are not concerned with harmonics of such a high order.

Written out as far as the 2nd harmonic, the series looks like this:

$$\begin{aligned} y &= 0.3 + 1.9099(0.3090 \sin t \\ &\quad + 0.5878 \frac{\sin 2t}{2} \\ &\quad + 0.8090 \frac{\sin 3t}{3} + \dots) \end{aligned}$$

Simplifying the coefficients, by dividing by n (1, 2, 3, ...):

$$\begin{aligned} y &= 0.3 + 1.9099(0.3090 \sin t \\ &\quad + 0.2939 \sin 2t \\ &\quad + 0.2700 \sin 3t + \dots) \end{aligned}$$

The values of $\sin(n\pi/10)$ increase for the first few terms, so this partly offsets the effect of dividing them successively by 1, 2, 3, ... In consequence, the first few harmonics are almost as strong

as the fundamental as shown in **Fig. 140**. This is plotted as far as the 10th harmonic (there is no 9th). Compared with the square wave of **Fig. 135**, as shown in **Fig. 137**, there is much less fall-off in the lower harmonics of

this pulse wave. This property of pulse waveforms is made use of in synthesizer circuits. A pulse waveform is a strong source of harmonics which can be filtered (formant filtering) to adjust their proportions until the resultant

sound has the timbre of a given musical instrument. Although the amplitude of the higher harmonics falls off more significantly, the limits of audibility are reached around the 5th harmonic. However, there is an increase of amplitude from the 10th to the 14th, which has an amplitude almost equal to that of the 7th harmonic. This illustrates the fact that unexpectedly strong harmonics may be present in pulse signals.

Other periods

The formulae described above all refer to a waveform in which one cycle takes 2π seconds. In other words, the angular velocity is unity. This corresponds to a frequency of 0.159 Hz. This is rather lower than many of the frequencies we meet in electronic circuits and, even though the analysis of different waveforms is independent of the frequency of the fundamental, there are many instances when we want to know the Fourier coefficients for a frequency that is **not** 0.159 Hz. Adapting the formulae to another frequency is just a matter of altering the time-scale.

The equations relating angular velocity, ω , frequency, f , and period (length of cycle), T , are:

$$\begin{aligned} \omega &= 2\pi/T \\ \text{or} \\ T &= 2\pi/\omega. \end{aligned}$$

The phase angle at any given time t is ωt . The Fourier series in these conditions is the same as before, except that we replace t in the cosine and sine terms by ωt . Conversely, making $\omega = 1$ restores the terms to their original form.

The formulae for the constant term is:

$$A_0 = \frac{1}{T} \int_0^T F(t) \, dt$$

The formulae for the coefficients are:

$$a_n = \frac{2}{T} \int_0^T F(t) \cos n\omega t \, dt$$

$$b_n = \frac{2}{T} \int_0^T F(t) \sin n\omega t \, dt$$

These show the limits of integration running from 0 to T , but they can also run from $-T/2$ to $T/2$ if this makes the integration any easier.

We will derive the Fourier series for the square wave of **Fig. 135**, but with a period of

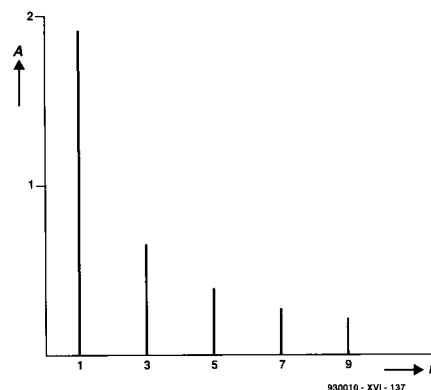


Fig. 137

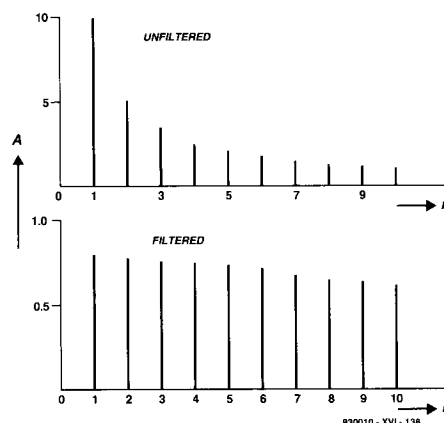


Fig. 138

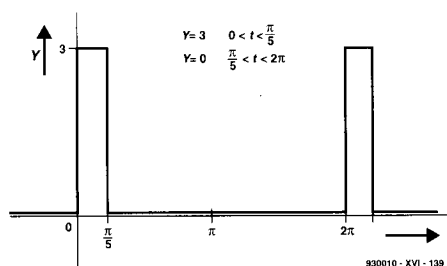


Fig. 139

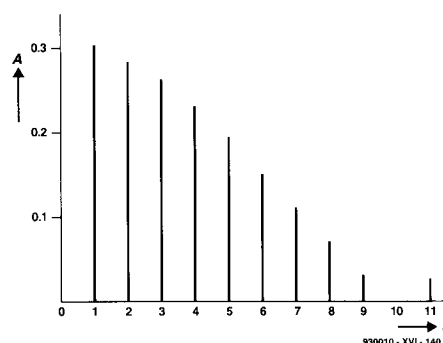
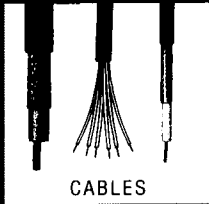


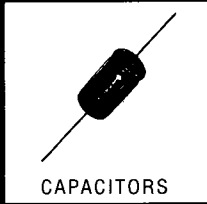
Fig. 140

Please mention **ELEKTOR ELECTRONICS** when contacting advertisers

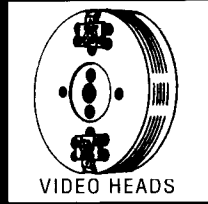
Call us now! We have the widest range of components available - At competitive prices!



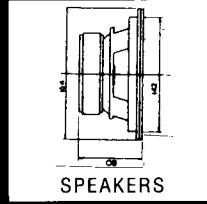
CABLES



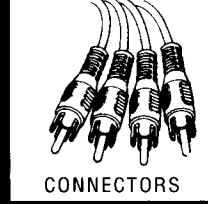
CAPACITORS



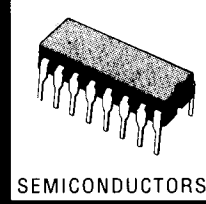
VIDEO HEADS



SPEAKERS



CONNECTORS



SEMICONDUCTORS

CRICKLEWOOD ELECTRONICS

Cricklewood Electronics Ltd. 40 Cricklewood Broadway, London NW2 3ET.
Telephone: 081 452 0161 Faxsimile: 081 208 1441

All Major Credit Cards Accepted



0.01 s., corresponding to a frequency of 100 Hz. At 100 Hz, $T = 0.001$ and $\omega = 2\pi/0.001 = 628.3$ rad.

The average value of y is not affected by the frequency, so $A_0 = 1.5$ as before. Also, as before, we recognize this to be an odd function, so that $a_n = 0$ and there are no cosine terms. For the sine terms:

$$b_n = \frac{2}{0.01} \int_0^{0.005} 3 \sin n\omega t \, dt$$

$$= \frac{-3}{0.005n\omega} (\cos n\pi - 1)$$

If n is even, $\cos n\pi = 1$, and $b_n = 0$. There are no even terms. If n is odd, $\cos n\pi = -1$ and $b_n = 6/0.005n\omega = 1.9099/n$.

The series is exactly the same as that for the square wave of **Fig. 135**, except that, instead of $\sin t$, $\sin 3t$, ..., we now have $\sin \omega t$, $\sin 3\omega t$, ... The graph of the series has the same shape, except that the scale on the x -axis runs from 0 to 0.001 s. Thus, all that we have said about waveforms with a period of 2π applies with little modification to periods of other lengths.

By contrast with the slow fall-off of harmonics in pulse waveforms, there are other waveforms in which the rate of fall-off is rapid. An example is shown in **Fig. 141**. This is the waveform of a half-wave rectified alternating voltage. The coefficients for the cosine terms are given by

the equation

$$a_n = \frac{2}{\pi(1-n^2)}$$

The denominator contains n^2 and successive coefficients (there are even terms only) are: $2/3\pi$, $2/15\pi$, $2/35\pi$, $2/63\pi$, ... The se-

ries has only a single sine term, so this has no effect on the rapid fall-off of the harmonics.

At this point we leave the discussion of the Fourier Series, having shown how to analyse many of the most commonly occurring waveforms. Often the in-

tegrations are long, and prone to error, especially with the frequent changes in sign that result from integrating functions containing sines and cosines. The rules we have discussed will help by eliminating the need for some of the integrations. When you have arrived at the equation for a series, plotting it with a graphic calculator is a rapid means of checking that it is essentially correct.

Test yourself

1. To what categories do the waveforms of **Fig. 142** each belong. In each case state what elements you would expect to find in their Fourier series.
2. A sawtooth waveform with period 2π is defined by these equations:
 $y = 3t \quad 0 < t < \pi$
 $y = 3t - 3\pi \quad \pi < t < 2\pi$
 Derive its Fourier series.

Answers to

Test yourself (Part 15)

$a_0 = 2\pi$; $a_n = 0$; $b_n = -4/n$.
 Series is: $y = 2\pi - 4\sin t - 2\sin 2t - 1.333\sin 3t - \sin 4t$...
 Filtered signal is
 $u_{out} = -3.988\sin(t - 0.0808) - 1.975\sin(2t - 0.1608) - 1.297\sin(3t - 0.2358) - 0.9525\sin(4t - 0.3098)$...

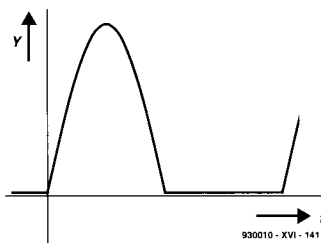


Fig. 141

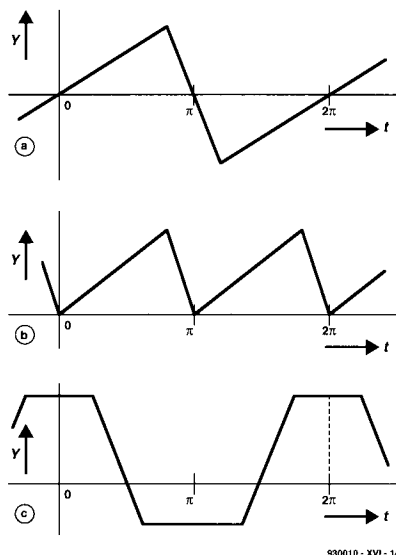


Fig. 142

LOW-VOLTAGE MONITOR

Design by J. Ruitters

During experimental work, the power supply is often variable or derived from a mains adaptor. In such cases, it is important to eliminate the risk of damaging ICs through overvoltage. The unit described in this article is intended for monitoring the supply voltage when the standard multimeter is already in use for other purposes.

Although electronic circuits on test should preferably be powered by a supply whose output voltage can be set accurately and is provided with a current limiting facility, in practice this is not always available. If a quickly put together supply is used on the test bench or with experimental work, ideally, two multimeters should be to hand: one for monitoring the supply voltage and the other for carrying out measurements on the circuit. If only one is available, the present monitor may prove useful.

The monitor is suitable for use with voltages in the ranges 2.0–6.0 V, 4.5–5.5 V, 3.0–15.0 V and one set by the user between 0 V and 14 V.

Apart from monitoring direct voltages, the unit may be used to react to sudden changes in voltages. This is, for instance, convenient for checking equipment that has a difficult-to-find, randomly occurring fault. Such equipment may be left operating on the test bench with the monitor attached. If a sudden change in voltage occurs in it, the monitor may indicate this by emitting a squeak from an optional buzzer.

The circuit

The circuit—see **Fig. 1**—is based on two comparators: IC_{1a} and IC_{1b}. These measure the input voltage on terminals A and B against accurately known potentials. These reference voltages are provided by variable zener diode D₁ and potential dividers R₈-P₂, R₉-P₃ and R₂-R₇. The zener voltage can be set accurately to exactly 2.5 V with P₁. Resistor R₁ is the standard series resistor that prevents the zener drawing too large a current.

Divider chain R₂-R₇ provides a number of fixed reference voltages, which are selected by S₁.

Dividers R₈-P₂ and R₉-P₃ provide the (variable) reference voltage that is determined by the user.

If the voltage on terminals A and B rises above, or falls below, set values, D₂ (red) or D₃ (green) lights respectively. If the input voltage lies between two set values, the two diodes light simultaneously. It is also possible to use buzzers as indicators, which eliminates the need to keep

an eye on the LEDs.

The input voltage is also applied to potential divider R₁₀-R₁₁ (1:6). The (scaled down) input voltage is applied to the non-inverting (+) input of IC_{1a} and to the inverting (–) input of IC_{1b}. When the potential at one terminal of the comparators becomes larger or smaller than that at the other input, the relevant comparator changes state. At that instant, the voltage at terminal A is exactly six times the reference voltage applied to the other terminal of the toggling comparator by S₁.

To give a range over which the input voltage may be considered safe, the com-

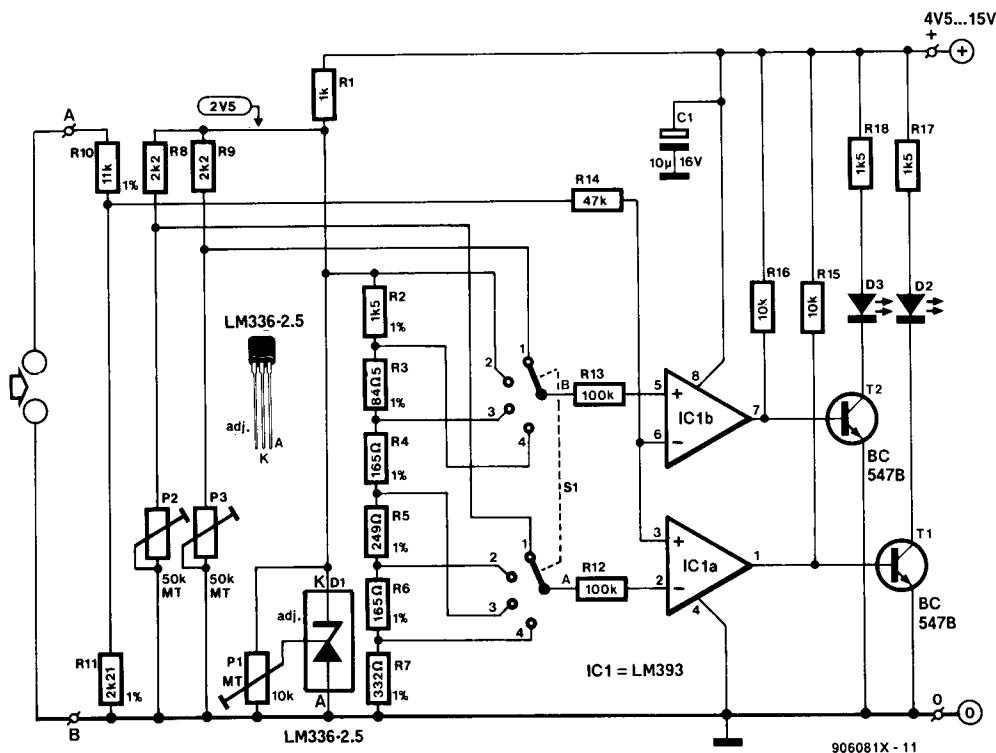
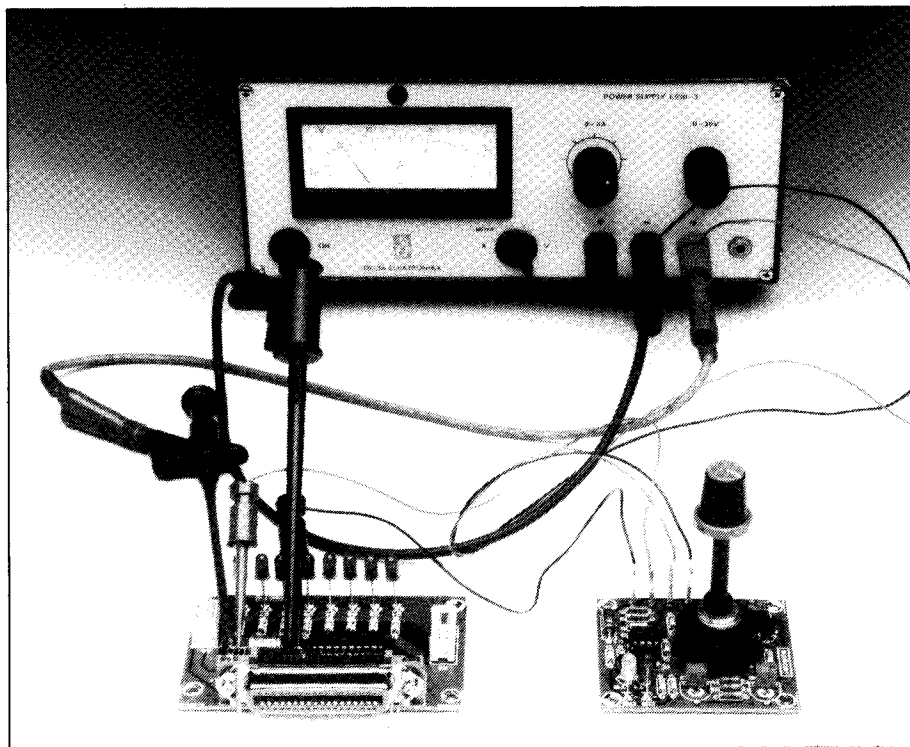
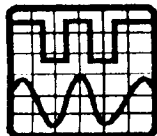
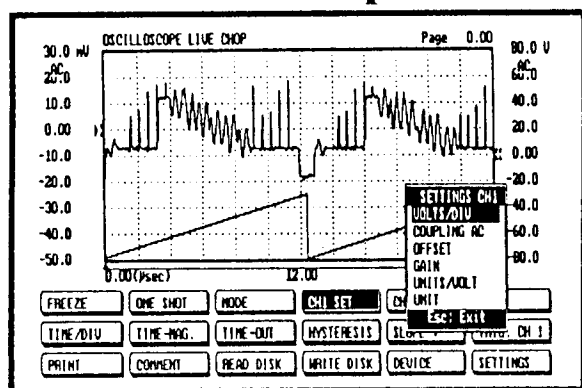


Fig. 1. Circuit diagram of the low-voltage monitor.

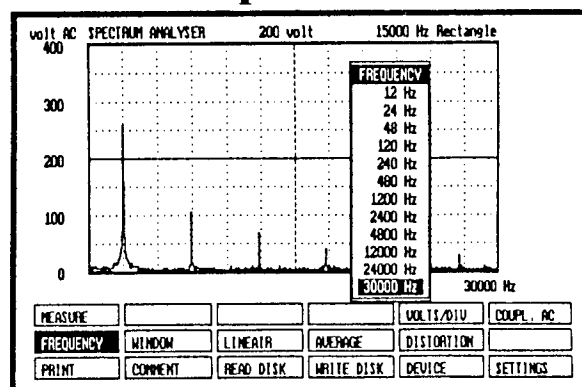


TEST and MEASURE with your COMPUTER.

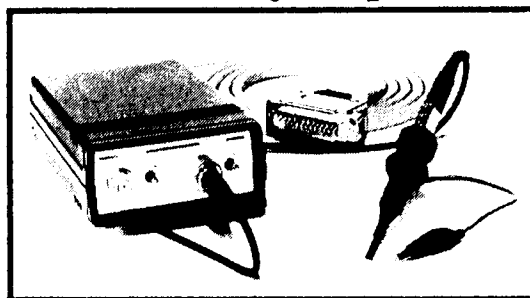
Oscilloscopes



Spectrum



Handyscope



PRINTER PORT

BUS SLOT

MULTI INSTRUMENTS

COLOUR SOFTWARE

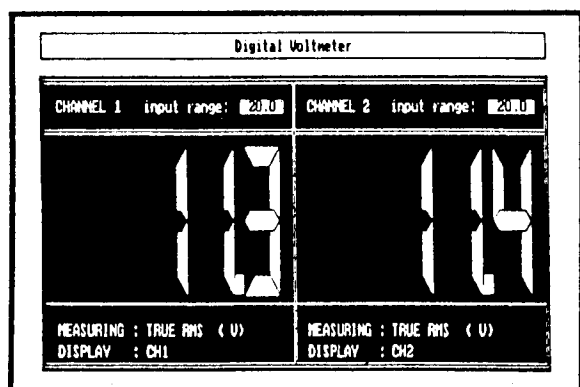
DUAL CHANNEL

BI-POLAR

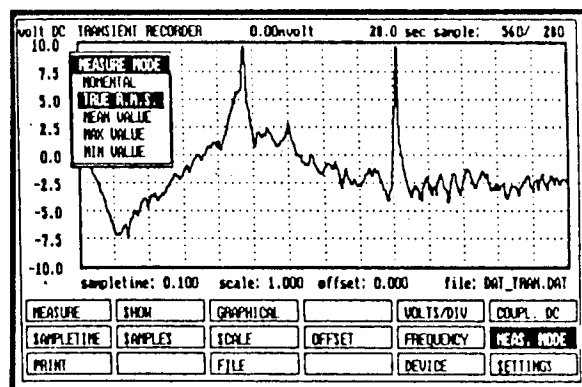
ACCURACY 0.25%

400V peak-peak

Multimeter



Transient



For more information on the HANDYSCOPE and other data acquisition instruments please contact...

INSTRUTEK (UK)

TEL: (0480) 460028 FAX: (0480) 460340.

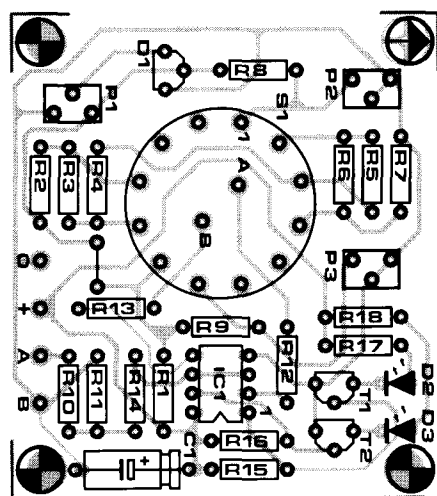
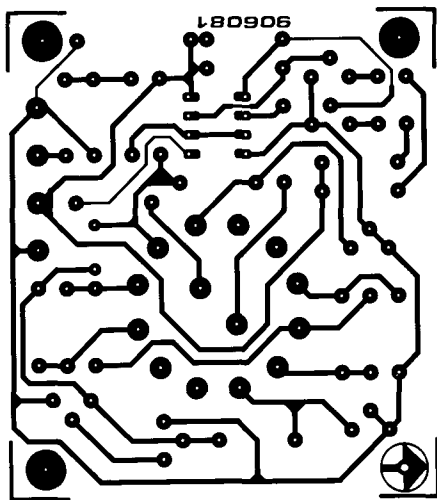


Fig. 2. Printed-circuit board for the low-voltage monitor

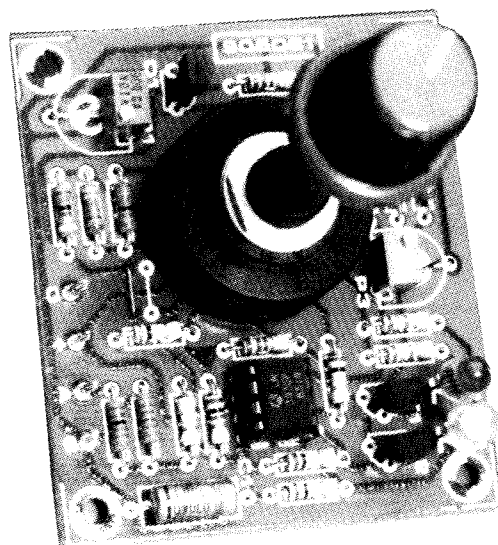


Fig. 3. Photograph of the prototype low-voltage monitor.

parator stages are designed in a manner which prevents their toggling at the same input level. This range with S_1 in position 1 is 2.0–6.0 V (HC/HCU ICs); in position 2, 4.5–5.5 V (HCT/TTL ICs); in position 3, 3.0–15.0 V (4xxx ICs); and in position 4 as required by the user between 0 V and 14 V. Note that section S_{1b} provides the upper reference voltages, and S_{1a} , the lower ones.

Since the input voltage is applied to different terminals of the comparators, these stages behave in opposite ways. For instance, with high input voltages, the output of IC_{1a} is high and that of IC_{1b} is low, whereas with low input voltages, the output of IC_{1a} is low and that of IC_{1b} is high.

The divergent behaviour of the comparators affects the operation of indicator networks T_1 – D_2 and T_2 – D_3 . When one of the comparator outputs is high, the associated transistor conducts, whereupon the allied LED lights. This means that if the input voltage is higher than the upper reference voltage D_2 lights and when it is below the lower reference voltage, D_3 lights. When the level of the input voltage lies between the two reference potentials, both LEDs light.

If it is desired to have an audible indication of voltage changes, a 0.1–1 μ F capacitor (not electrolytic) must be connected in series with terminal A. The input is then taken from the equipment on test as stated earlier. The buzzer should be connected to the monitor circuit as shown in Fig. 4.

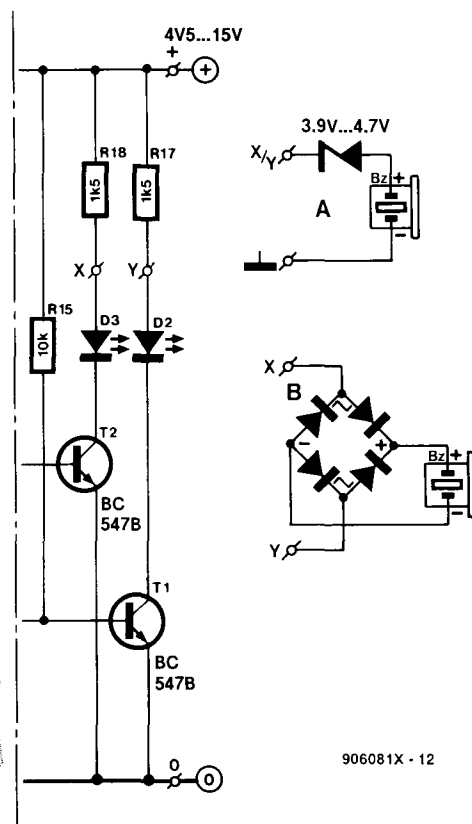


Fig. 4. Various ways of connecting an optional buzzer (or buzzers) to the monitor.

Construction

The monitor is best built on the printed-circuit board shown in Fig. 2 (not available ready made). The completed prototype is shown in Fig. 3.

The monitor may be constructed as a stand-alone unit or be built into an existing equipment. In the former case, the enclosure may be given a front panel as shown in Fig. 5 (not available ready made, but the picture may be photocopied and glued behind a transparent panel).

If a buzzer is used and it is desired that this squeaks when the input voltage is too high, connect its +ve terminal to 'x' in Fig. 4, and its –ve terminal to ground. A second buzzer may be connected to indicate too low input voltages: this should be connected between 'y' and ground. The zener diode in series with the buzzer prevents its squeaking faintly when the relevant transistor conducts.

It is also possible to use only one buzzer, which should be connected via a bridge rectifier to 'x' and 'y'. In this case, the buzzer is silent when the input voltage lies in the safe range, but it squeaks when the input goes outside this range.

It is advisable to use small buzzers that draw a current of not more than 1–3 mA (at 5–12 V).

The monitor may be powered conveniently from a mains adaptor. The supply voltage may be 4.5–15 V. At 9 V, it draws a current of about 30 mA.

When the construction has been completed, adjust P_1 to obtain a voltage of exactly 2.500 V, measured with a digital

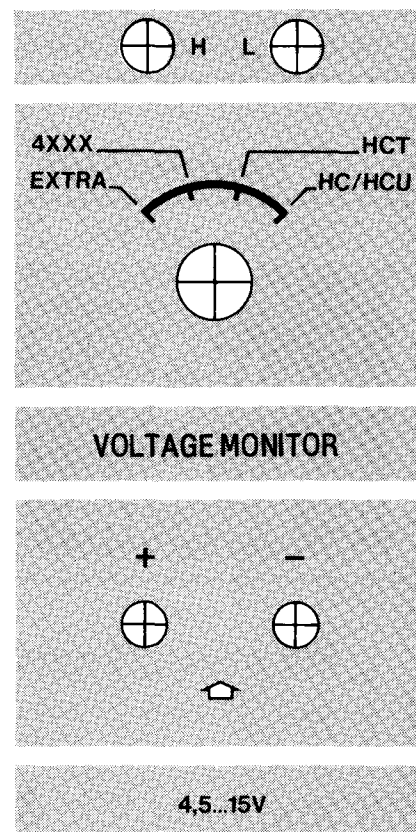


Fig. 5. Suggested front panel for the low-voltage monitor.

New Innovation In Electronic CAD Software

Integrated Analogue Filter Design & Simulation

All Design Calculations Fully Automated

Features:-**Network Designer Version 1.2****Filter Design**

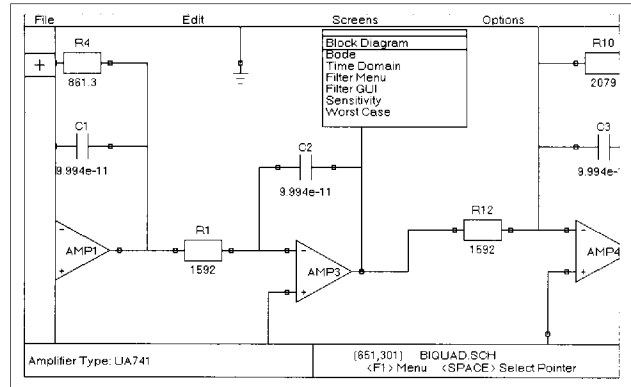
- Design Both Active & Passive Filters By Using **The Filter GUI**
- Includes All Popular Filter Realisations (Inc Butwth & Cheby)
- Edit Circuits, Round Component Values & Set Tolerances
- Generate SPICE Netlists, Print Circuits & Component Lists

System Modelling

- Design Complex Feedback & Feedforward Systems
- Edit Transfer Function Block Names & Contents
- Implement Systems As Circuits In Seconds
- Calculate System Function Up To 20th Order

Simulation

- Internal Simulation Package Based On Berkeley SPICE
- Carry Out AC, Transient, Sensitivity & Worst Case Analysis
- Up To Four Graphs Shown At The Same Time
- Trace Graphs & Display X-Y Co-ordinates

**All This For Only £275 !!****Call For Your Free Interactive Demo Disk****SigCad Ltd Tel: 0203 597797**

Requires PC 286/386/486 Compatibles And Runs Under DOS
Access, Eurocard, Delta, Mastercard, Visa Welcome
(Price Excludes P&P And VAT)

BADGER BOARDS

Printed Circuit Boards for Amateur Radio Schools Colleges
Short Wave Listeners Clubs Hobbyists & Industry

A range of Printed Circuit Boards in stock from many of the Projects in Magazines
PRACTICAL WIRELESS ☐ **SHORT WAVE MAGAZINE** ☐ **ELEKTOR** ☐ **HRT**
RADIO COMMUNICATION

Kits Projects and Materials for manufacturing your own boards. Artwork and Plotting from your own Schematic drawings and also C.A.D. facilities. We supply ONE OFF Prototypes Phone between 9.00am and 5.30pm Monday to Friday for helpful advice and assistance Club talks and demonstrations of Printed Circuit Board manufacture QRP involvement etc

021-353 9326

87, Blackberry Lane, Four Oaks, Sutton Coldfield. B74 4JF
(Please mention where you spotted this advertisement)

80C31 / 51 / 535 / 515

Programming and Interfacing with Microcontrollers; This 250+ page book gives a comprehensive hands-on approach to show how microcontrollers are programmed and interfaced to external circuitry to perform useful automation and control functions. A number of routines, including floating-point arithmetics, are included in this book and on the accompanying disk which also includes a crossassembler. (£65)

FLASH; Fuzzy-Logic Applications Software Helper, is a code generator which creates routines and tables in the MCS-51 assembly language to implement Fuzzy-Logic control applications. (£120)

Other related products and services are available. For more Information please write to the address below or just send a fax.

**KMN Developments, P.O. Box 70, Guildford,
Surrey GU2 5ZY United Kingdom
Fax No. +44 (0)483/570722**

voltmeter, across D_1 (or P_1). Make sure that the type coding of D_1 is LM336-2.5.

Range 4 is set with a variable power supply, set to the desired voltage, and a voltmeter across input terminals A and B. Adjust P_3 until the green LED just goes out and P_2 until the red LED just goes out.

Finally, make sure that terminal A is clearly marked + and terminal B -. Polarity reversal would not do the comparators any good.

Parts list**Resistors:**

$R_1 = 1 \text{ k}\Omega$

$R_2 = 1.5 \text{ k}\Omega$, 1%

$R_3 = 84.5 \Omega$, 1%

$R_4, R_6 = 165 \Omega$, 1%

$R_5 = 249 \Omega$, 1%

$R_7 = 332 \Omega$, 1%

$R_8, R_9 = 2.2 \text{ k}\Omega$

$R_{10} = 11 \text{ k}\Omega$, 1%

$R_{11} = 2.21 \text{ k}\Omega$, 1%

$R_{12}, R_{13} = 100 \text{ k}\Omega$

$R_{14} = 47 \text{ k}\Omega$

$R_{15}, R_{16} = 10 \text{ k}\Omega$

$R_{17}, R_{18} = 1.5 \text{ k}\Omega$

$P_1 = 10 \text{ k}\Omega$, 10 turns preset

$P_2, P_3 = 50 \text{ k}\Omega$, 10 turns preset

Capacitors:

$C_1 = 10 \mu\text{F}$, 16 V

Semiconductors:

$T_1, T_2 = \text{BC547B}$

$D_1 = \text{LM336-2.5}$

$D_2 = \text{LED, red}$

$D_3 = \text{LED, green}$

Integrated circuits:

$\text{IC}_1 = \text{LM393}$

Miscellaneous:

$S_1 = 2\text{-pole, 6-position rotary switch, with suitable knob}$

Enclosure (if required) 120x65x40 mm ($4\frac{3}{4} \times 2\frac{1}{2} \times 1\frac{1}{2}$ in), e.g. Bopla E430BB – represented in UK by Phoenix Mecano Ltd, telephone (0296) 398 853.

NEW BOOKS

INSANELY GREAT

The story of the Macintosh, the computer that changed the life of computer users

By Steven Levy

Price £ 15.00

Coinciding with the news that Apple Computer Inc. was the largest PC maker in the USA in 1993, comes a new book on the history of the Apple Macintosh, the computer that can be used by everybody without having to remember bewildering sets of commands that are forgotten as soon as they are typed in. Moreover, even the very first Macintosh did not use blinding green or orange screens that made the user see 'green' even after only a short spell of working on rival computers and which have given rise in most western nations to legislation protecting the operator. No, the Macintosh had a monitor that showed black letters on a white background, just like a book or magazine, and altogether kinder on the eyes.

All Macintosh computers can be used without almost any training: just point the mouse and type away; intricate commands are not required. One of the best compliments that can be paid to the Macintosh is that its rivals have adopted a similar operating system (called 'Windows'). At the time of writing this review, that system has not yet achieved the versatility of the Macintosh.

Some years ago, the Macintosh had the disadvantage of being more expensive than MS-DOS machines. Over the past few years, Macintosh prices have, however, come tumbling down and they are now comparable to, and in some case even lower than, those of MS-DOS computers of similar performance.

No wonder that service industries, like insurance, accountancy, and newspaper, magazine and book publishers in the main use Apple computers, not because of cost considerations, but because they employ computer **operators** rather than computer **technicians**.

The reasons for the development of the Macintosh are made clear in this fascinating book by Steven Levy. It should be compulsory reading for management in most companies, many of whom now use computers that are not really suited to their operators.

Viking, 27 Wright's Lane, London W8 5TZ. Telephone 071 938 2200.

POWER ELECTRONIC CONVERTERS DC-AC CONVERSION

By Guy Séguier & Francis Labrique

ISBN 3 540 54974 9

Price £ 71.00 (hard cover)

This fourth and final volume of the Power Electronic Converters series is devoted to DC-AC conversion. DC-AC converters have

seen considerable development over recent years, one the one hand because of the difficulties related to filtering and on the other because of the possibilities offered by new semiconductors.

The first chapter of the book describes the principles of inverters and explains the choice and weighing of topics. In the following chapters, the different types of inverter are described in great detail with an emphasis on their application in practice. **Springer-Verlag London Ltd, Sweet Apple House, Cotteshall Road, Godalming GU7 3DJ. Telephone 0483 418 800.**

DATA ACQUISITION AND PROCESS CONTROL WITH THE M68HC11 MICROCONTROLLER

By Frederick F. Driscoll, Robert F.

Coughlin and Robert S. Villanucci

ISBN 0-02-330555-X

Price £ 25.95 (hard cover)

The real fun in using microcontrollers starts when you are able to do something useful with such a 'beast'.

This book should be of special interest to readers who have constructed the 68HC11 processor board described in the April 1994 issue of *Elektronics*.

The book addresses the entire scope of using the 68HC11 microprocessor for instrumentation and control systems. Various skills must be mastered before such applications can be made to work as they should. The book shows how these many skills can be organized effectively by employing an engineering design procedure with practical application examples.

The first four chapters of the book are devoted to the MC68HC11 microcontroller and an Evaluation Board system obtained from Motorola. This system runs a monitor program called Buffalo¹, which stands for Bit User Fast Friendly Aid to Logical Operation. Buffalo offers a number of fairly basic commands like moving blocks of memory, calling addresses, go, input/output, block fill, etc., but also more advanced stuff like an assembler/disassembler, and debug functions like trace and breakpoint.

Next come two chapters which may be called hybrids because they detail software consideration and hardware design procedures to both acquire input data and provide output control with the microcontroller.

The last three chapters deal extensively with data acquisition and control problems with complete hardware and software designs given, and each problem explained. The example programs are presented in the form of neatly formatted assembly language listings with plenty of comment to assist in understanding the operation.

Most of the chapters take the form of a tutorial, closed off with problems and software assignments.

The appendices contain, among others, the complete instruction set and datasheets of the 68HC11, as well as datasheets of some of the transducers used in the projects

described elsewhere in the book.

Macmillan Publishing Company, New York, USA (UK distributors: until; 31 May 1994: Marston Book Services, telephone (0865) 791 155; from 1 June 1994: Paramount Publishing, Campus 400, Maylands Avenue, Hemel Hempstead HP2 7EZ; telephone (0442) 881 900.

¹ Buffalo may be downloaded from the Motorola BBS in Munich, Germany and Austin, Texas, as described in *Elektronics* April 1994.

LINEAR CIRCUIT ANALYSIS & DRAWING By Ian Sinclair

ISBN 0 7506 1662 8

Price £ 14.95

This book has many applications in any small development workshop in which costs must be kept down, and any user who has a need to find what a linear circuit is likely to do, and how best to draw the circuit, can make good use of the book.

The book introduces the principles of linear analysis and shows what is required to analyse a variety of common circuits with the use of a large number of examples. The linear analysis program used as an example in this, the first, part of the book is Aciran, one of the best available. Its installation and setting up is fully explained, bearing in mind that readers are likely to know more about electronics than about computing.

The second half of the book is concerned with circuit diagrams. The preparation of precise and printable circuit diagrams is a chore that plagues small-scale electronics workshops. In the past, circuit diagrams of camera-ready standard required the employment of a capable draughtsperson and took an inordinate amount of time and expense. The use of a low-cost CAD program, such as AutoSketch, makes it possible to automate this process and turn out drawings of a very high standard with none of the painstaking effort that was formerly required.

Installation of AutoSketch is described in detail, as is how individual component symbols can be brought or created to any required scale. The book then shows how circuit diagrams can be built up.

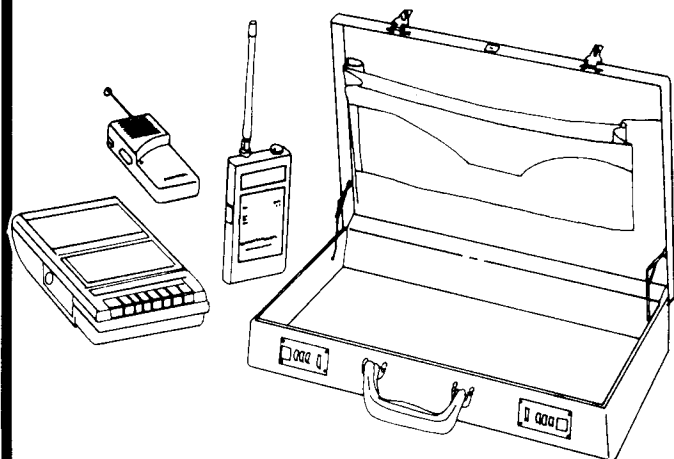
This is not a book for newcomers to linear circuits, but should be of interest to students, technician engineers, interested amateurs and anyone concerned with linear circuit development work.

Butterworth-Heinemann, Linacre House, Jordan Hill, Oxford OX2 8DP. Telephone (0865) 310 366.

SURVEILLANCE

A SMALL SAMPLE OF OUR RANGE

	KIT	MODULE	PROF. FINISHED
ROOM TRANSMITTER RT1 An extremely sensitive miniature transmitter with long battery life. Dimensions: 20 x 20mm	9.95	13.75	19.00
MAINS TRANSMITTER MT4 Can be connected inside any equipment that is mains powered. Dimensions 35 x 20mm	19.75	31.50	45.00
TELEPHONE TRANSMITTER TTS Small enough to conceal within a telephone. Will transmit both sides of a conversation (series connection) Dimensions: 10 x 20mm	12.75	17.50	25.00
TELEPHONE SOCKET TRANSMITTER TSTS Replace your telephone socket with this one within which a transmitter has been concealed.	14.74	---	29.00
ROOM AND TELEPHONE TRANSMITTER RTT Operates as a room transmitter, then switches to telephone transmitter mode during telephone calls. Dimensions: 30 x 25mm	31.50	45.50	65.00
AUTOMATIC TELEPHONE RECORDER SWITCH TRS2 Record telephone conversations with this interface unit and your own tape recorder. Dimensions: 36 x 50mm	16.80	25.90	38.00
AUTOMATIC TELEPHONE RECORDER ATR1 Adapt the tape recorder included to record telephone calls automatically.	34.95	---	59.00
TELEPHONE TAP ALERT TTA1 Visual warning of any invasions of privacy on your telephone line. Dimensions: 38 x 52mm	21.95	31.50	45.00
RF DETECTOR RFD1 Highly sensitive hand-held detector. Range between 10MHz and 600MHz. Silent operation. Dimensions: 70 x 50mm	42.75	69.00	95.00
CAMERA DETECTOR CD8 Detects hidden video cameras (even miniature CCD models). Dimensions: 63 x 38mm	69.00	89.00	125.00
RECORDING BRIEFCASE RBC1 Completely discreet recordings at a value for money price.	---	---	145.00
SHOTGUN MICROPHONE AMPLIFIER SMA Ideal for surveillance. The amplifier will pick up sounds from a long distance.	24.95	36.00	45.00
SIGNALLING TRANSMITTER SIGT Sends a continual audio pulse. Can be integrated into alarm, tracking or warning systems. Dimensions: 20 x 50mm	21.95	34.89	45.00
TELEPHONE AMPLIFIER TA5 Connected directly to the telephone, this unit will amplify both sides of a telephone call. Dimensions: 25 x 52mm	10.95	16.95	19.95
PROFESSIONAL SOUND TO LIGHT UNIT SK72 Custom built for disco or home use. Audio signal divided into bass, mid and treble bands, with internal microphone and spotlight option. Dimensions 210 x 45mm	21.95	32.49	44.95
MICRO METAL DETECTOR MMD Detect the presence of ferrous and various non-ferrous metals. Useful for all those DIY jobs. Dimensions: 40 x 25mm	9.95	16.95	---



Please add £2.00 P & P to all orders and 17.5% VAT on all U.K. orders.

For full catalogue please send two 1st class stamps or 2 IRC'S

172 Caledonian Road
Dept EL

CANAL

London N1 0SG

BRIDGE AUDIO

071-837 4423



COPY PROTECTION SYSTEMS

Are you looking for reliable copy protection for your software products ?

Intar's copy protection devices meet the standards of demanding industrial environments. Intar produces a wide range of copy protection devices from standard parallel port "dongles" to specialized ISA-cards. Intar supplies customer customized high performance copy protection devices. Low price and high quality are Intar's trademark.

When looking for proper copy protection,

Software Protection Devices

ask for Intar's solution !

Hard Environment

Prices for parallel port model

£ 18 (qty 1), £ 14 (qty 100)



INTAR OY, P.O.BOX 70, FIN-00511, HELSINKI, FINLAND, Fax: +358-0-148-4382

BUILD YOUR OWN P.C.

Motherboards

386SX-40MHZ	£72
386DX-40MHZ 128K CACHE	£99
486SX-33MHZ 256K CACHE	£159
486DX-33MHZ 256K CACHE	£279
486DX-40MHZ 256K CACHE	£299
486DX2-50MHZ 256K CACHE	£290
486DX-50MHZ 256K CACHE	£369
486DX2-66MHZ 256K CACHE	£399
Complete w/in VESA Local Bus - 3 Slots & Pentium P24T socket. For EISA motherboards please ring	

Add-on Cards

I/O Card 2S/1P/1G	£12
IDE Card 2HD/2FD with Cables	£12
IDE I/O Card 2HD/2FD/2S/1P1Gw/cables	£16
VL-Bus IDE I/O card as above	£29
VL-Bus IDE caching controller 4HD2FD	£129
VL-Bus SCSI-2 IDE //Ocard	£125
SCSI-2 card with software	£89
16-bit Ethernet Card (NE2100 compatible)	£59

Display Cards

16-bit SVGA with 256k	£25
16-bit SVGA with 512k	£30
16-bit SVGA with 1MB	£49
VL-Bus SVGA w/in 1MB	£70
VL-Bus SVGA w/in 2MB	£99
VL-Bus S3 Windows Accelerator 1MB	£110
VL-Bus S3 Windows Accelerator 2MB	£140

Tape streamers

Jumbo 120MB Tape Streamer	£119
Jumbo 250MB Tape Streamer	£149

Floppy Disk Drives

5 1/4" 1.2MB Floppy Disk Drive	£35
3 1/2" 1.44MB Floppy Disk Drive	£33
3 1/2" 1.44MB Floppy with 5 1/4" Frame	£36

Hard Disk Drives

130MB IDE 16ms	£150
170MB IDE 15ms	£159
213MB IDE 14ms	£179
250MB IDE 14ms	£189
330MB IDE 12ms	£229
420MB IDE 12ms	£360
540MB IDE 12ms	£430
1GB SCSI 9ms	£699
2GB SCSI 10ms	£980

Monitors

14" SVGA Colour Monitor (0.28mm)	£175
14" Non-Interlaced Colour Monitor	£199
14" Mono VGA Monitor	£89

Cases

Deluxe Desktop Case	£55
Mini-Tower Case	£59
Tower Case	£89

Other Items

102-Key Keyboard	£22
Mouse (with Software)	£12
256Kx9 SIMM 70ns	£13
1MBx9 SIMM 70ns	£36
4MBx9 SIMM 70ns	£125
MS-DOS 6.0	£39
Mitsumi CD-ROM drive & Interface card	£129
Toshiba XM3401 db/s SCSI CD Rom	£295

Please ring for a copy of our **FREE** catalogue TODAY.
prices exclude VAT & carr. Access & Visa cards welcome.

Eurocom International Ltd

The Old School, Prickwillow, Ely, Cambs, CB7 4UN. Tel / Fax (0353 88325)



IF AN
ADVERT IS WRONG,
WHO PUTS IT RIGHT?

We do. The Advertising Standards Authority ensures advertisements meet with the strict Code of Advertising Practice.

So if you question an advertiser, they have to answer to us.

To find out more about the ASA, please write to
Advertising Standards Authority,
Department X, Brook House,
Torrington Place, London WC1E 7HN.



This space is donated in the interests of high standards in advertisements.

USING THE DOUBLE BALANCED MIXER (DBM)

In radio frequency electronics a mixer is a non-linear circuit or device that permits frequency conversion by the process of heterodyning. Mixers are used in the 'front-end' of the most common form of radio, the superheterodyne (regardless of wave band), in certain electronic instruments and in certain measurement schemes (receiver dynamic range, oscillator phase noise, etc). This article looks at a very popular mixer circuit, the double balanced type.

By Joseph J. Carr, B.Sc., M.S.E.E.

THE block diagram for a basic mixer system is shown in Fig. 1; this diagram is generic in form, but also represents the front-end of superheterodyne radio receivers. The mixer has three ports: F_1 receives a low-level signal, and would correspond to the RF input from the aerial in radio receivers; F_2 is a high-level signal, and corresponds to the local oscillator (LO) in superhet radios; and F_3 is the resultant mixer product (corresponding to the **intermediate frequency** or 'IF' in superhet radios). These frequencies are related by:

$$F_3 = mF_1 \pm nF_2 \quad (1)$$

Where:

F_1 , F_2 and F_3 are as described above;
 m and n are counting numbers (zero plus integers 0, 1, 2, 3, ...)

In any given system, m and n can be zero, or any integer, but in practical circuits it is common to consider only the first, second and third order products. For sake of simplicity, let us consider a first-order circuit ($m=n=1$). Such a mixer would output four frequencies: F_1 , F_2 , $F_{3a} = F_1 + F_2$, and $F_{3b} = F_1 - F_2$. In terms of a radio receiver, these frequencies represent the RF input signal, the local oscillator signal, the **sum IF** and the **difference IF**. In radios, it is common practice to select either sum or difference IF by filtering, and rejecting all others.

There are a number of different types of mixer circuit, but only a few different classes: **single-ended**, **single balanced** (or simply 'balanced') and **double balanced**. Most low-cost superheterodyne radio receivers use single-ended mixers, although a few of the more costly 'communications receiver' models use singly or double balanced mixers for improved performance. This article focusses on the double balanced mixer (DBM) because it offers superior performance over the other forms, but is not as well known in electronic hobby circles.

One of the advantages of the DBM over the other forms of mixer is that it sup-

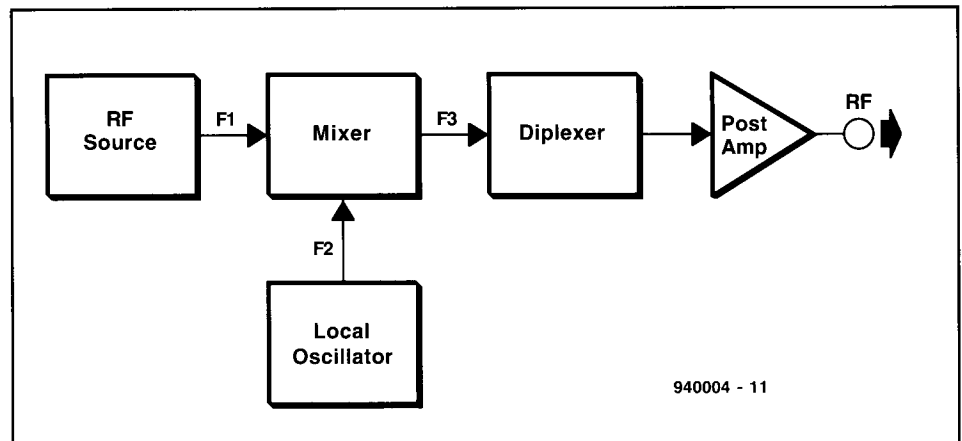


Fig. 1. Block diagram of a mixer used as a frequency converter.

presses F_1 and F_2 components of the output signal, passing only the sum and difference signals. In a radio receiver using a DBM, the IF filtering and amplifier would only have to contend with sum and difference IF frequencies, and not bother with the LO and RF signals. This effect is seen in DBM specifications as the port-

to-port isolation figure, which can reach 30 to 60 dB depending on DBM model.

A **diplexer** stage is shown in Fig. 1, and is used to absorb unwanted mixer products, and pass desired frequencies. These frequency selective circuits are discussed below.

A **post-amplifier** stage is typically

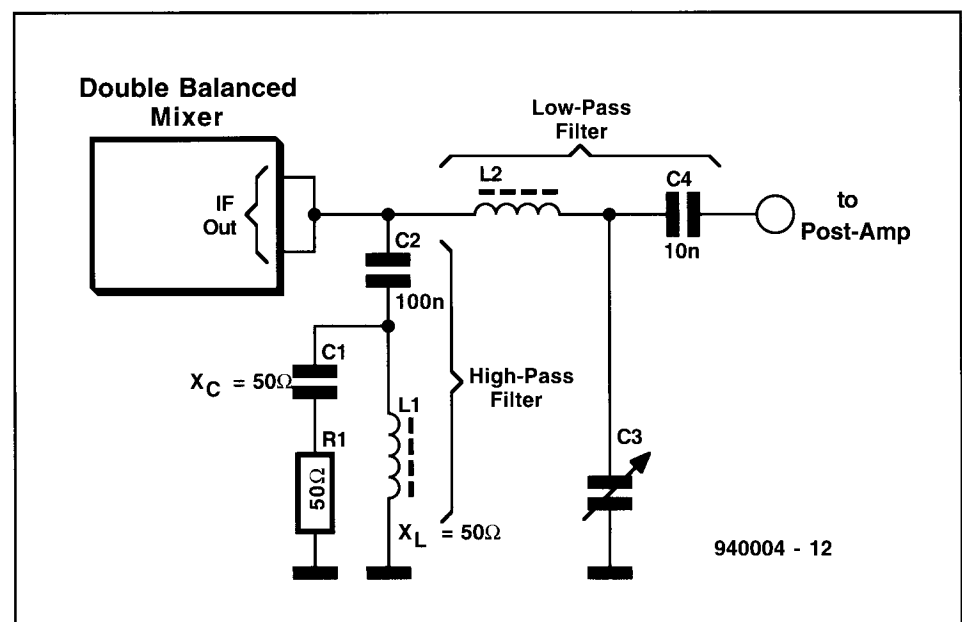


Fig. 2. Diplexer circuit based on low-pass and high-pass filters.

included because the insertion loss of most passive DBMs is considerable (5 to 12 dB). The purpose of the amplifier is to make up for the loss of signal level in the mixing process. Some active DBMs, incidentally, have a **conversion gain** figure, not a loss. For example, the popular **Signetics** NE602 device offers 20 dB of conversion gain.¹

Diplexer circuits

The RF mixer is like most RF circuits in that it wants to be terminated in its characteristic impedance. Otherwise, a standing wave ratio (SWR) problem will result, causing signal loss and other problems. In addition, certain passive DBMs (of which, more below) will not work well if improperly terminated. A number of different diplexer circuits are known, but two of the most popular are shown in **Figs. 2** and **3**.

A diplexer has two jobs: 1) it absorbs undesired mixer output signals, so they are not reflected back into the mixer, and 2) it transmits desired signals to the output. In **Fig. 2**, these goals are met with two different *LC* networks; a high-pass filter and a low-pass filter. The assumption in this circuit is that the difference IF is desired, so a high-pass filter with a cut-off above the difference IF is used to shunt the sum IF (plus and LO and RF signals that survived the DBM process) to a dummy load (R_1). The dummy load shown in **Fig. 2** is set to 50 Ω because that is the most common system impedance for RF circuits (in practice, a 51- Ω resistor might be used). The dummy load resistor can be a 1/4-watt unit in most low-level cases, but regardless of power level it must be a noninductive type (e.g. carbon composition or metal film).

The inductor (L_1) and capacitor (C_1) values in the high pass filter are designed to have a 50- Ω reactance at the IF frequency. These values can be calculated from:

$$L = \frac{50 \Omega}{2\pi F_3} \quad (2)$$

$$C = \frac{1}{2\pi F_3 (50 \Omega)} \quad (3)$$

Where L is in henrys, C is in farads, and F_3 is in hertz.

The low-pass filter transmits the desired difference IF frequency to the output, rejecting everything else. Like the high-pass filter, the L and C elements of this filter are designed to have reactances of 50 Ω at the difference IF frequency.

Recently I built a sweep generator to facilitate an high performance AM band (540-1700 KHz) receiver that I am designing. The sweeper circuit is a varactor tuned VCO driven with a 45-Hz sawtooth wave. The swept oscillator is heterodyned against a 14-MHz crystal oscilla-

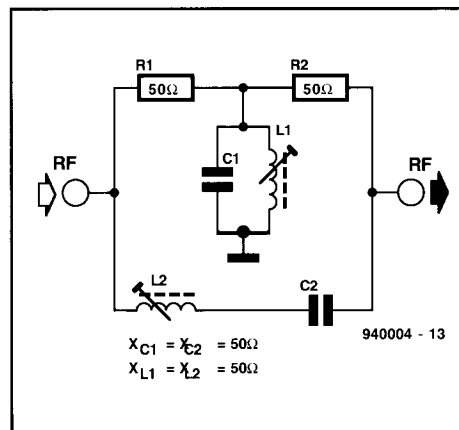


Fig. 3. Diplexer circuit based on series and parallel resonant circuits.

tor, producing difference frequencies which can be tuned to either 455 KHz (my selected IF), or any frequency in the AM band. My diplexer unit consists of two 3,000-KHz Butterworth filters, one high-pass and the other low-pass; each filter consists of five reactance elements. The high-pass filter was terminated in a 50- Ω dummy load made by paralleling two 100- Ω metal film resistors (which were hand-selected for the correct value). The low-pass filter was terminated in a post amplifier with a 50- Ω input impedance.

Another popular diplexer circuit is shown in **Fig. 3**. This circuit consists of a parallel resonant 50- Ω tank circuit (C_1 - L_1), and a series resonant 50- Ω tank circuit (C_2 - L_2). The series resonant circuit passes its resonant frequency while rejecting all others because its impedance is low at resonance and high at other frequencies. Alternatively, the parallel resonant tank circuit offers a high impedance to its resonant frequency, and a low impedance to all other frequencies.

Because C_1 - L_1 are shunted across the signal line, it will short out all but the resonant frequency.

In direct conversion receivers, a mixer is used to down convert CW and SSB signals directly to audio by setting F_2 close to F_1 , without using an IF amplifier chain. In those receivers it is common practice to build a diplexer similar to **Fig. 4**. Capacitor C_1 passes high frequencies (which are RF), and they are absorbed in a 50- Ω dummy load. The low-frequency audio signals (300 to 3,000 Hz) are passed by a 50- Ω low-pass filter consisting of L_1 , L_2 , L_3 , R_2 and C_2 .

JFET and MOSFET DBMs

Junction field effect transistors (JFETs) and metal oxide field effect transistors (MOSFETs) can be arranged in a ring circuit that provides good double balanced mixer operation. **Figure 5** shows a circuit that is based on JFET devices. Although discrete JFETs such as MPF102 or its equivalents can be used in this circuit with success, performance is generally better if the devices are matched, or are part of a single IC device (e.g., the U350 IC). With due attention to layout and input/output balancing, the circuit is capable of better than 30 dB port-to-port isolation over an octave (2:1) frequency change.

The inputs and output of this circuit are based on broadband RF transformers. These transformers are bifilar and trifilar wound on toroidal cores. The input circuit consists of two bifilar wound impedance transformers (Tr_1 and Tr_2). The LO and output circuits are trifilar wound RF transformers. Part of the output circuit includes a pair of low-pass filters which also serve to transform the 1.5 to 2 k Ω impedance of the JFET de-

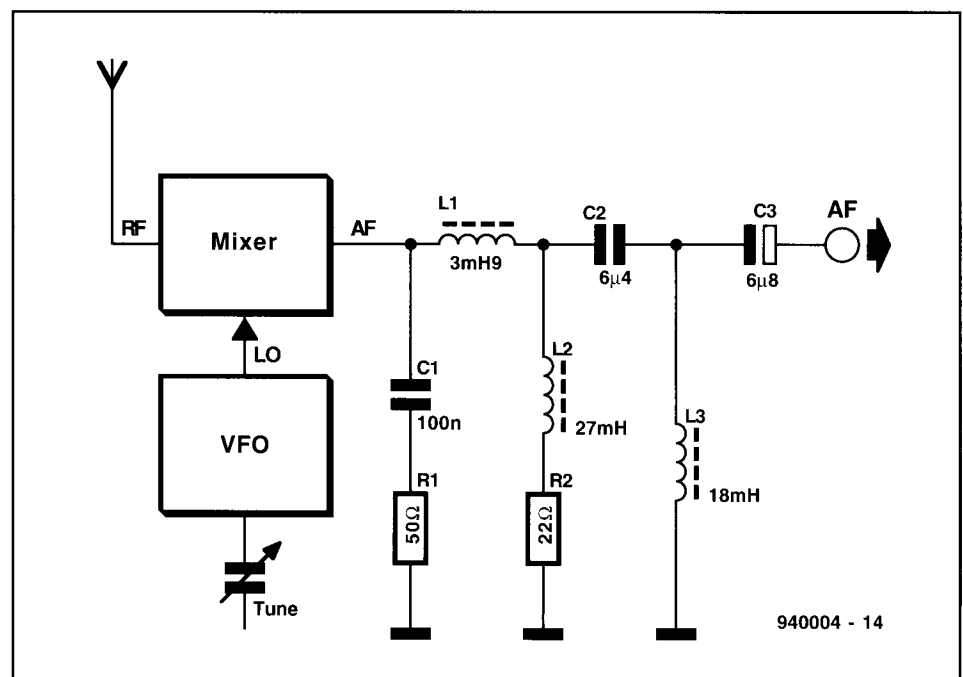


Fig. 4. Diplexer for a direct conversion receiver. Note: R_2 changed to 50 ohms if L_2 is ideal.

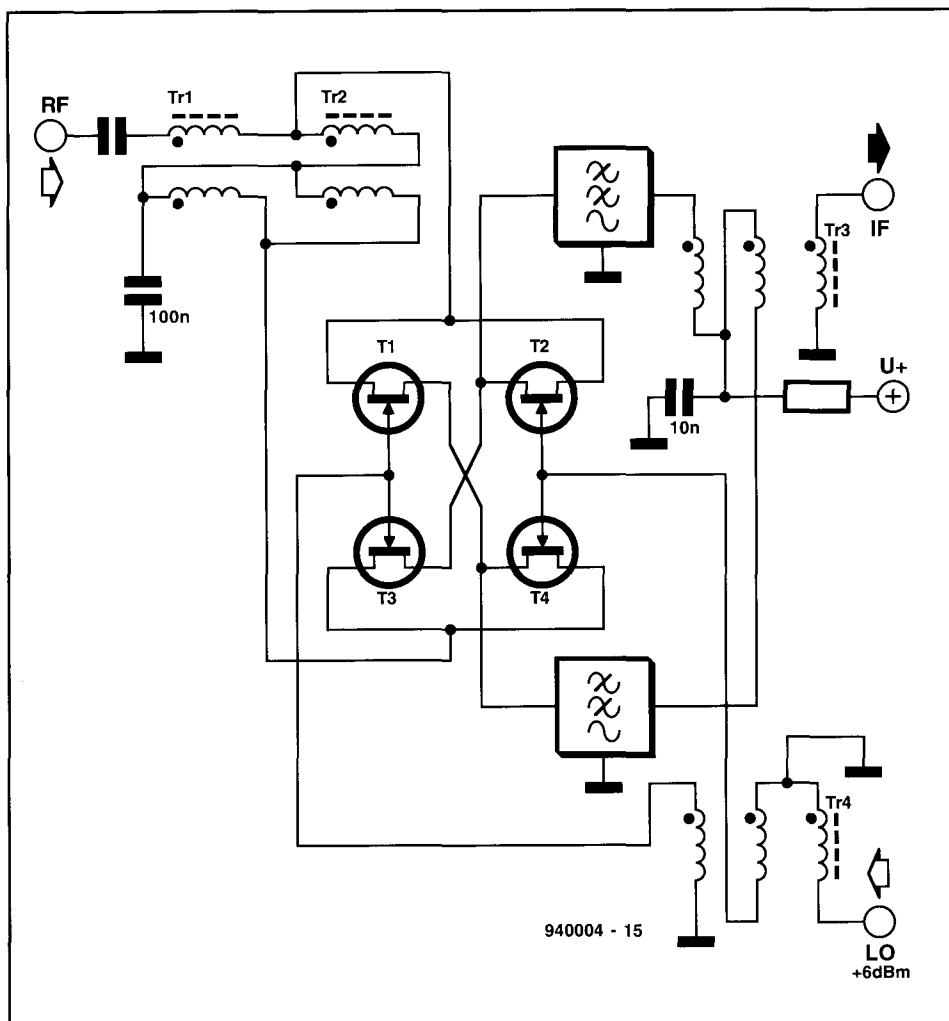


Fig. 5. DBM circuit based on JFET transistors.

vices to 50 Ω . As a result of the needed impedance transformation, the filters must be designed with different R_{in} and R_{out} characteristics, and that fact complicates the use of look-up tables (which would be permitted if the input and output resistances were equal).

Double balanced diode mixer circuits

One of the most easily realized double balanced circuits, whether homebrew or commercial, is the circuit of Fig. 6. This circuit uses a diode ring mixer and balanced input, output and LO ports. It is capable of 30 to 60 dB of port-to-port isolation, yet is reasonably well-behaved in

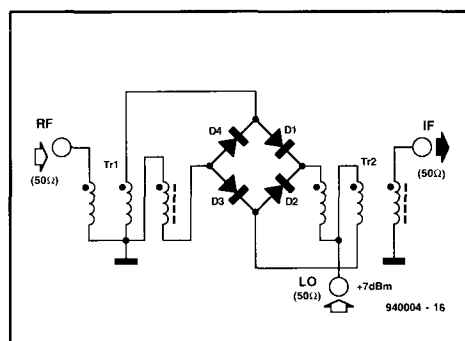


Fig. 6. Diode double balanced mixer.

practical circuits. DBMs such as Fig. 6 have been used by electronic hobbyists and radio amateurs in a wide variety of projects from direct conversion receivers to single sideband transmitters and high-performance shortwave receivers. With proper design, a single DBM can be made to operate over an extremely wide frequency range; several models claim operation from 1 to 500 MHz, with IF outputs from d.c. to 500 MHz.

The diodes (D_1 through D_4) can be ordinary silicon VHF/UHF diodes such as 1N914 or 1N4148. However, superior performance is expected when Schottky hot-carrier diodes, such as 1N5820 through 1N5822 are used instead. Whatever diode is selected, all four devices should be matched. The best matching of silicon diodes is achieved by comparison on a curve tracer, but failing that there should at least be a matched forward/reverse resistance reading. Schottky hot-carrier diodes can be matched by ensuring that the selected diodes have the same forward voltage drop when biased to a forward current of 5 to 10 mA.

Figure 7a shows the internal circuitry for a very popular commercial diode DBM device, the Mini-Circuits SRA-1 and SBL-1 series; a typical SRA/SBL package is shown in Fig. 7b.

These devices offer good performance, and are widely available to hobbyists and radio amateur builders. Some parts houses sell them at retail, as does **Mini-Circuits** [P.O. Box 166, Brooklyn, NY, 11235, USA: phone 714-934-4500]². I do not know the amount of their minimum order, but I have had **Mini-Circuits** in the USA respond to \$25 orders on several occasions ... which is certainly more reasonable than other companies.

The packages for the SRA/SBL devices are similar, being of the order of 20 mm long with 5-mm pin spacing. The principal difference between the packages for SRA and SBL devices is in the height. In these packages, pin no. 1 is denoted by a blue bead insulator around the pin. Other pins are connected to the case or have a green (or other colour) bead insulator. Also, the 'MCL' logo on the top can be used to locate pin 1: the 'M' of the logo is directly over pin 1. Table 1 shows the characteristics of several DBMs in the SRA and SBL series, while Table 2 shows the pin assignments for the same devices.

In the standard series of devices, the RF input can accommodate signals up to +1 dBm (1.26 mW into 50 Ω), while the LO input must see a +7 dBm (5-mW) signal level for proper operation. Given the 50- Ω input impedance of all ports of the SRA/SBL devices, the RF signal level must be kept below 700 mV_{pp}, while the LO wants to see 1400 mV_{pp}. It is essential that the LO level be maintained across the band of interest, or else mixing operation will suffer. Although the device will work down to +5 dBm, a great increase in spurious output and less port-to-port isolation is found. Spectrum analyzer plots of the output signal at low LO drive levels show considerable second and third-order distortion products.

Note the IF output of the SRA/SBL de-

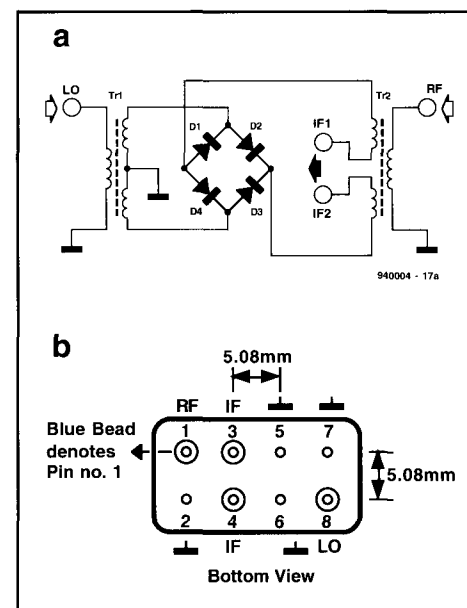


Fig. 7. (a) Mini-Circuits SRA/SBL series DBMs; (b) typical Mini-Circuits DBM package.

At last, a fully functional upgradeable PCB CAD system to suit any budget. Substantial trade-in discounts are available against other "professional" PCB design packages ...

... call now for details.

Board Capture

Schematic Capture Design Tool

£395

- Direct netlist link to BoardMaker2
- Forward annotation with part values
- Full undo/redo facility (50 operations)
- Single-sheet, multi-paged and hierarchical designs
- Smooth scrolling
- Intelligent wires (automatic junctions)
- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
- Extensive component-based power control
- Back annotation from BoardMaker2

BoardMaker

BoardMaker1 - Entry level

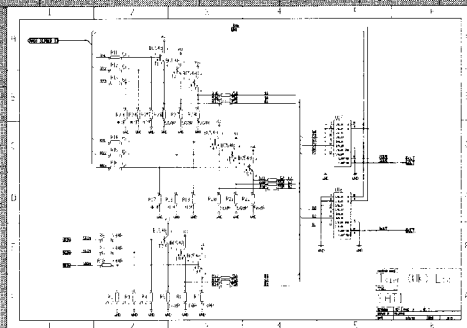
£95

- PCB and schematic drafting
- Easy and intuitive to use
- Surface mount and metric support
- 90, 45 and curved track corners
- Ground plane fill
- Copper highlight and clearance checking

BoardMaker2 - Advanced level

£295

- All the features of BoardMaker1 +
- Full netlist support - BoardCapture, OrCad, Schema, Tango, CadStar and others
- Full Design Rule Checking both mechanical and electrical
- Top down modification from the schematic
- Component renumber with back annotation
- Report generator - Database ASCII, BOM
- Thermal power plane support with full DRC



NEW

Board Router

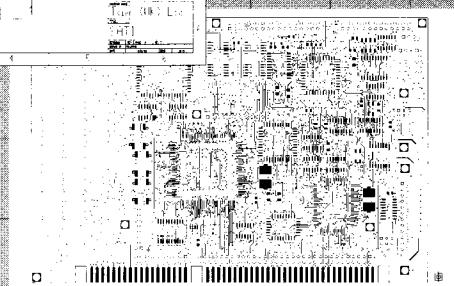
Gridless re-entrant autorouter

£200

- Simultaneous multi-layer routing
- SMD and analogue support
- Full interrupt, resume, pan and zoom while routing

Output drivers - Included as standard

- Printers - 9 & 24 pin Dot matrix, HPLaserjet and PostScript
- Penplotters - HP, Graphtec & Houston
- Photoplotters - All Gerber 3X00 and 4X00
- Excellon NC Drill and Annotated drill drawings (BM2)



Call, write or fax for more information

or a full evaluation kit

Tsien (UK) Limited

Aylesby House

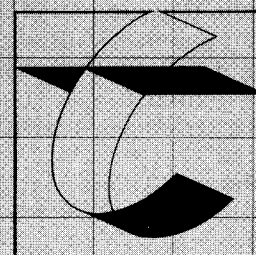
Wenny Road, Chatteris

Cambridge

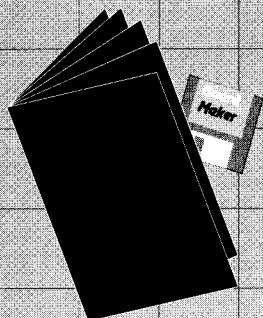
PE16 6UT

Tel (0354) 695959

Fax (0354) 695957



tsien



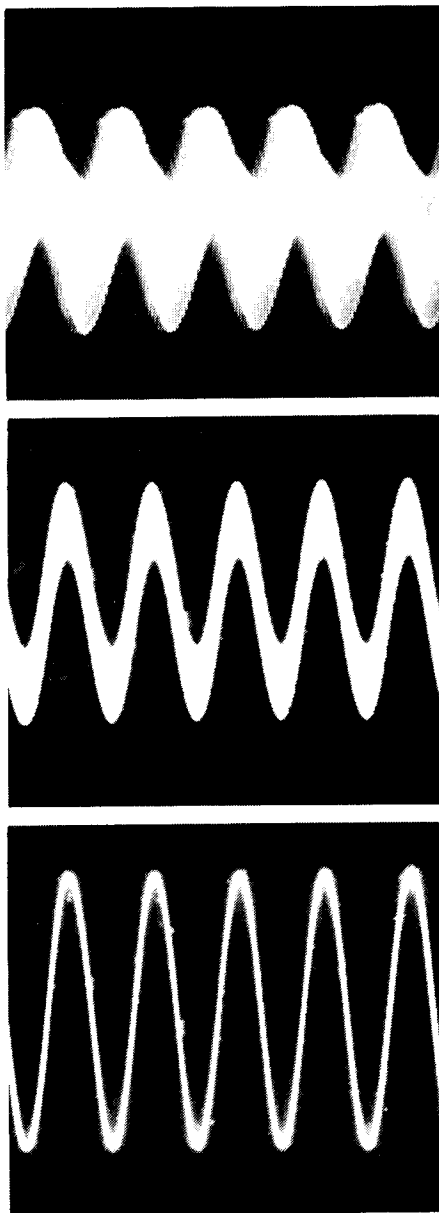


Fig. 8. Waveforms from a circuit using the Mini-Circuits DBM: (a) improperly terminated; (b) with part of diplexer disconnected; (c) output waveform when diplexer is connected.

vices. Although some models in the series use a single IF output pin, most of these devices use two pins (3 and 4), and these **must** be connected together externally for the device to work.

As is true with most DBMs, and all diode ring DBM circuits, the SRA/SBL devices are sensitive to the load impedance at the IF output. Good mixing, and freedom from the LO/RF feedthrough problem, occurs when the mixer looks into a low-VSWR load. For this reason, a good diplexer circuit is required at the output. In experiments, I have found that unterminated SBL-1-1 mixers produce nearly linear mixing when not properly terminated...and that is not what is desired in a frequency converter.

The effects of the termination impedance on the operation of the diode DBM circuit are shown in Fig. 8. The oscilloscope photo in Fig. 8a shows the mixer

Type No.	LO/RF (MHz)	IF (MHz)	Mid-Band Loss (dB)
SRA-1	0.5-500	DC-500	5.5-7.0
SRA-1TX	0.5-500	DC-500	5.5-7.0
SRA-1W	1-750	DC-750	5.5-7.5
SRA-1-1	0.1-500	DC-500	5.5-7.5
SRA-2	1-1000	0.5-500	5.5-7.5
SBL-1	1-500	DC-500	5.5-7.0
SBL-1X	10-1000	5-500	6.0-7.5
SBL-1Z	10-1000	DC-500	6.5-7.5
SBL-1-1	0.1-400	DC-400	5.5-7.0
SBL-3	0.025-200	DC-200	5.5-7.5

Table 1. Main specifications of some commonly found diode double balanced mixers.

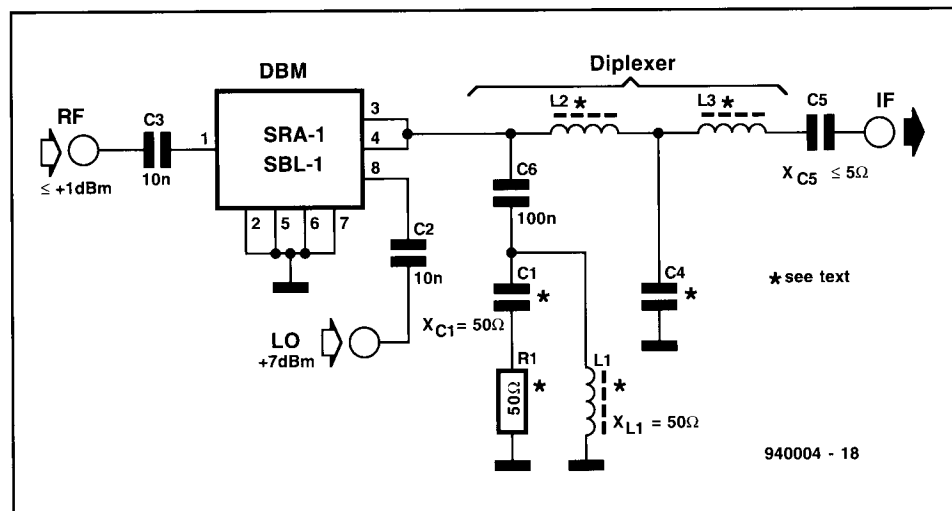


Fig. 9. Typical circuit using the Mini-Circuits SRA/SBL devices.

output directly at pins 3 and 4 of an SBL-1-1. Note that it is a complex waveform of mixed signals, and reflects the fact that the mixer is not properly terminated. The waveform at Fig. 8b was taken at the output of the low-pass filter when the high-pass filter and its associated dummy load was disconnected. At Fig. 8c is the resultant when properly matched high pass (and dummy load) and low pass filters were in operation. The waveform was a nearly clean sine wave of 455 KHz. Another waveform, not shown, was obtained when there was no high pass filter, but the DBM was terminated in a resistance matched to its char-

acteristic impedance and a low pass filter. It was a distorted sinewave, and reflected the fact that other products were present in the output signal.

Figure 9 shows a typical SRA/SBL circuit: RF drive ($\leq +1$ dBm) is applied to pin 1, and the +7 dBm LO signal is applied to pin 8. The IF signal is output through pins 3 and 4, which are strapped together. All other pins (2, 5, 6 and 7) are grounded.

The diplexer circuit consists of a high-pass filter (C_1-L_1) terminated into a 50- Ω dummy load for the unwanted frequencies, and a low-pass filter ($L_2-L_3-C_4$) for the desired frequencies. All capacitors

Type	LO	RF	IF	GND	Case GND
SRA-1	8	1	3,4	2,5,6,7	2
SRA-1TX	8	1	3,4	2,5,6,7	2
SRA-1-1	8	1	3,4	2,5,6,7	2
SRA-1W	8	1	3,4	2,5,6,7	2,5,6,7
SRA-2	8	3,4	1	2,5,6,7	2,5,6,7
SRA-3	8	1	3,4	2,5,6,7	2
SBL-1	8	1	3,4	2,5,6,7	—
SBL-1-1	8	1	3,4	2,5,6,7	—
SBL-3	8	1	3,4	2,5,6,7	—

Table 2. Pin function overview for diode DBMs.

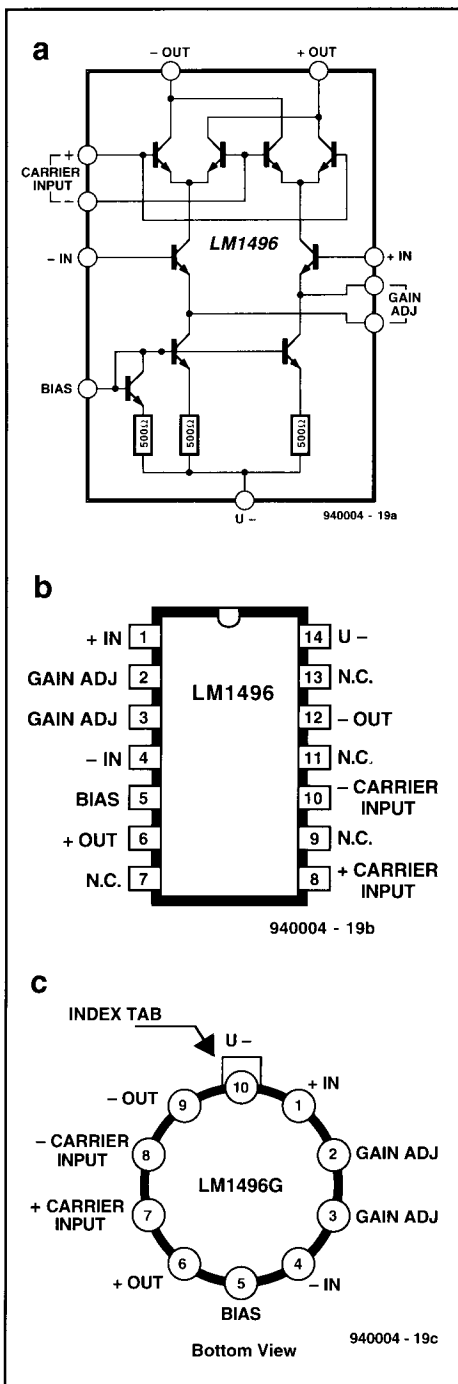


Fig. 10. (a) Internal circuitry for the LM1496 DBM; (b) DIP package for the LM1496; (c) metal can package for the LM1496.

and inductors are selected to have a reactance of 50 Ω at the IF frequency.

Sometimes 1-dB resistor π -pad attenuators are used at the inputs and the IF output of the DBM. In some cases, the input attenuators are needed to prevent overload of the DBM (overload causes spurious product frequencies to be generated, and may cause destruction of the device). In other cases, the circuit designer is attempting to 'swamp out' the effects of source or load impedance variations. Although this method works, it is better to design the circuit to be insensitive to such fluctuations, rather than to use a swamping attenuator. The reason is that the resistive attenuator causes a signal loss and adds to the noise gener-

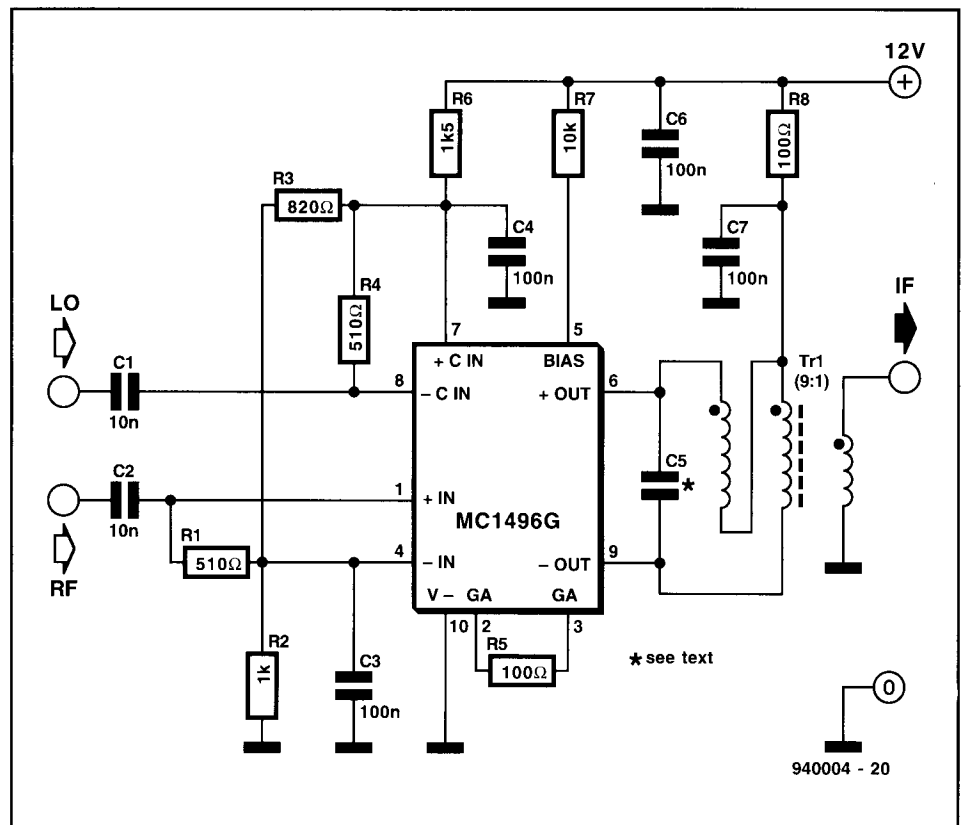


Fig. 11. Mixer circuit using the LM1496.

ated in the circuit (no resistor can be totally noise free). A good alternative is to use a stable amplifier with 50 Ω input and output impedances, and that is not itself sensitive to impedance variation, to isolate the DBM.

Mini-Circuits devices related to the SRA-1 and SBL-1 incorporate MAR-x series MMIC amplifiers internal to the DBM. One series of devices places the amplifier in the LO circuit, so that much lower levels of LO signal will provide proper mixing. Another series places the amplifier in the IF output port. This amplifier accomplishes two things: it makes up for the inherent loss of the mixer and it provides greater freedom from load variations that can affect the regular SRA/SBL devices.

Bipolar transconductance cell DBMs

Active mixers made from bipolar silicon transistors formed into Gilbert transconductance cell circuits are also easily available. Perhaps the two most common devices are the **Signetics** NE602 device and the LM1496 device (**Maplin** catalogue no. QH47B, p. 463 in 1993 edition).

The NE602 was discussed extensively in Ref. 1, to which the reader is referred for details on input, output and LO configurations.

The LM1496 device is shown in **Figs. 10a, 10b** and **10c**. **Figure 10a** shows the internal circuitry, while **Figs. 10b** and **10c** show the DIP and metal can packages, respectively. Pins 7 and 8 form the local oscillator (or 'carrier'

in communications terminology) input, while pins 1 and 4 form the RF input. These push-pull inputs are also sometimes labelled 'high level signal' (7 and 8) and 'low level signal' (1 and 4) inputs. D.c. bias (pin 5) and gain adjustment (pins 2 and 3) are also provided.

Figure 11 shows the basic LM1496 mixer circuit in which the RF and carrier inputs are connected in the single-ended configuration. The respective signals are applied to the input pins through d.c. blocking capacitors C_1 and C_2 ; the alternate pin inputs in both cases are bypassed to ground through capacitors C_3 and C_4 .

The output network consists of a 9:1 broadband RF transformer that combines the two outputs, and reduces their impedance to 50 Ω . The primary of the transformer is resonated to the IF frequency by capacitor C_5 .

Figure 12 shows a circuit that uses the LM1496 device to generate double sideband suppressed carrier (DSSC) signals. When followed by a 2.5 to 3-KHz bandpass filter, which is off-set from the IF frequency, this circuit will also generate single sideband (SSB) signals. In common practice, a crystal oscillator will generate the carrier signal (U_c), while the audio stages produce the modulating signal (U_m) from an audio oscillator or microphone input stage. I once saw a circuit that is very similar to this one in a signal generator/test set used to service both amateur radio and marine HF-SSB radio transceivers. It was the signal source to test the receiver sections of the transceivers. The carrier was set to

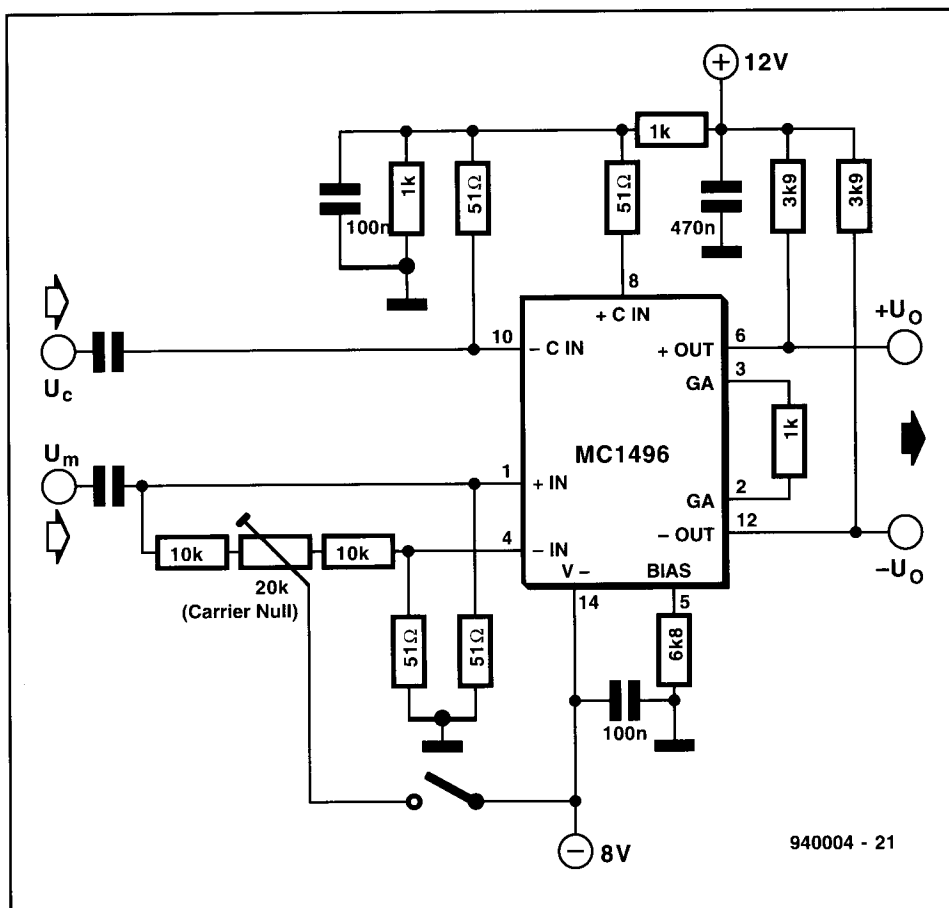


Fig. 12. Double sideband suppressed carrier (DSSC) generator circuit using the LM1496.

9 MHz, and both lower sideband (LSB) and upper sideband (USB) **KVG** crystal filters were used to select the desired sideband. An alternate scheme which is cheaper uses a single 9-MHz crystal filter, but two different crystals at frequencies either side of the crystal passband. One crystal would generate the USB signal, while the other would generate the

LSB signal.

For single sideband to be useful it has to be demodulated to recover the audio modulation. The circuit of **Fig. 13** will do that job nicely. It uses an LM1496 DBM as a **product detector**. This type of detector works on CW, SSB and DSB signals (all three require a local oscillator injection signal), and produces the audio

resultant from heterodyning the local carrier signal against the SSB IF signal in the receiver. All SSB receivers use some form of product detector at the end of the IF chain, and many of them use the LM1496 device in a circuit similar to **Fig. 13**.

Conclusion

Double balanced mixer circuits work better than most other mixer circuits in radio receivers, SSB transmitters/receivers, instrumentation and measurement situations. They are easy to use in most cases, and if properly designed into a circuit yield good results with minimum effort. ■

References:

1. 'NE602 primer', Joseph J. Carr, *Elektor Electronics* January 1992, pp. 20-25.
2. In the UK, contact Dale Electronics Ltd., Camberley, Surrey, tel. (025) 28 35094.

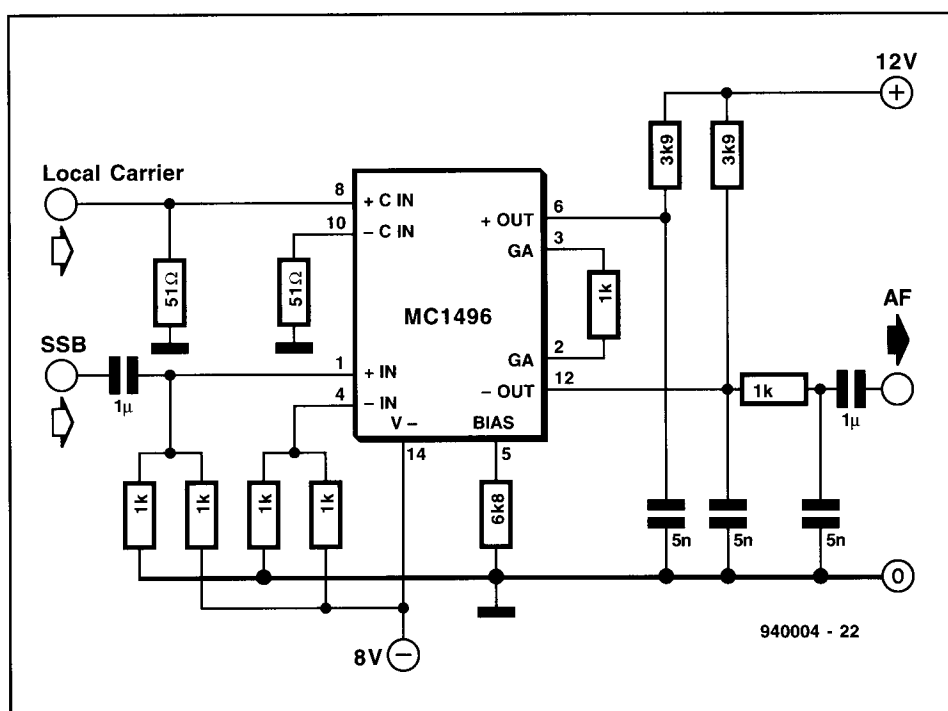
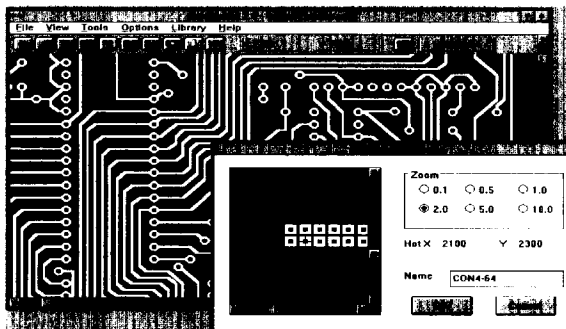


Fig. 13. Single-sideband/CW product detector for receiver using the LM1496.

"... there is no doubt that running under *Windows* puts it ahead of the field and makes it a visually attractive package." **Electronics World + Wireless World** July 1993

High Quality PCB and Schematic Design for Windows 3/3.1 and DOS

- Supports over 150 printers/plotters including 9 or 24 pin dot-matrix, DeskJet, LaserJet, Postscript, and HPGL. Professional Edition imports GERBER files, and exports GERBER and NC-DRILL files.
- Up to 200,000 pads/track nodes depending on memory. Simple auto-router and schematic capture tools with SPICE compatible net-list output.
- Low cost DOS version (reduced features) also available. Ring for full details!



"Quickroute provides a comprehensive and effective introduction to PCB design which is a pleasure to use" **Radio Communication** May 1993.



POWERware
Software •
• Design

POWERware, Dept EK, 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD, UK.

Contact Tel/Fax 061 449 7101 or write, for a full information pack.

Quickroute is available for Windows 3/3.1 in Professional (£99.00) and Standard (£59.00) editions and for DOS with reduced features (£49.00). All prices inclusive. Add £2 P&P for UK or £5 P&P outside UK

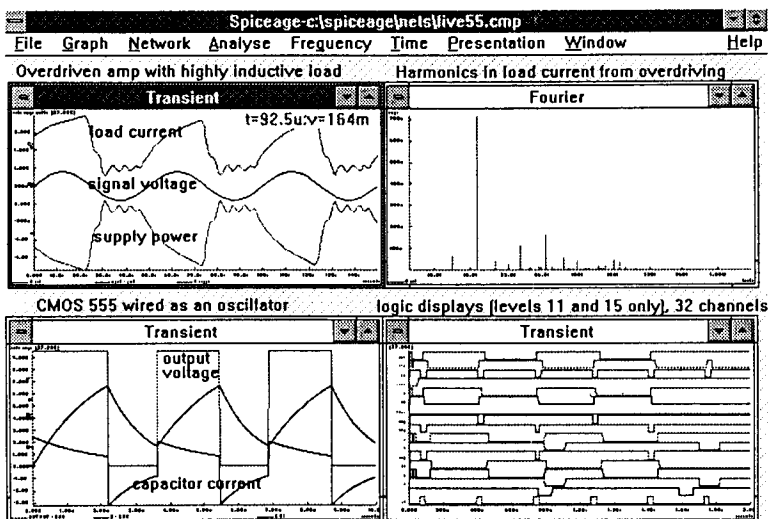
Quickroute

from

£49

SpiceAge Level 1 is now permanent thanks to you.

For just £100 including U.K. postage and VAT, you can have a copy of this remarkable circuit simulator program complete with the full manual on your doorstep tomorrow (80% of orders are currently despatched by return of post). And there is no surcharge for upgrading if you do this within 3 months of purchase. Requires Microsoft Windows 3.1 operating in enhanced mode.



Those Engineers Ltd



Please send £5 for demonstration kit or SAE for information pack to **Those Engineers Ltd, Dept K4, 31 Birkbeck Road, LONDON NW7 4BP** or Tel 081-906 0155 or FAX 081 906 0969.

VIEWDATA RETURNS £6 made by Tandata, includes 1200.75 modem, k/bd, RGB and comp o/p, printer port. No PSU. £6 MAG6P7

IBM PC CASE AND PSU Ideal base for building your own PC. Ex equipment but OK. £14.00 each REF: MAG14P2

SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit just £5.99 REF: MAG6P8

SOLID STATE RELAYS Will switch 25A mains. Input 3.5-26V DC 57x43x21mm with terminal screws £3.99 REF: MAG4P10

300DPI A4 DTP MONITOR Brand new. TTL/ECL inputs, 15" landscape, 1200x1664 pixel complete with circuit diag to help you interface with your projects. JUST £24.99. REF: MAG25P1

ULTRAMINI BUG MIC 6mmx3.5mm made by AKG, 5-12v electret condenser. Cost £12 ea, Our four for £9.99 REF: MAG10P2

RGB/CGA/EGA/TTL COLOUR MONITORS 12" in good condition. Back anodised metal case. £99 each REF: MAG99P1

GX4000 GAMES MACHINES returns so ok for spares or repair £9 each (no games). REF: MAG99P1

C64 COMPUTERS Returns, so ok for spares etc £9 ref: MAG99P2

FUSELAGE LIGHTS 3 foot by 4" panel 1/8" thick with 3 panels that glow green when a voltage is applied. Good for night lights, front panels, signs, disco etc. 50-100v per strip. £25 ref: MAG25P2

ANSWER PHONES Returns with 2 faults, we give you the bits for 1 fault, you have to find the other yourself. BT Response 200's £18 ea REF: MAG18P1, BT Response 400's £25 ea REF: MAG25P3 Suitable power supply £5 REF: MAG5P12

SWITCHED MODE PSU ex equip. 60w +5v @ 5A, -5v @ 5A, +12v @ 2A, -12v @ 5A 120/220v cased 245x88x55mm IEC input socket £6.99 REF: MAG7P1

PLUG IN PSU 9V 200mA DC £2.99 each REF: MAG3P9

PLUG IN ACORN PSU 19v AC 14w, £2.99 REF: MAG3P10

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref: MAG6P9

ACORN ARCHIMEDES PSU +5v @ 4.4A, on/off sw uncased, selectable mains input, 145x100x45mm £7 REF: MAG7P2

GEIGER COUNTER KIT Low cost professional twin tube, complete with PCB and components. £29 REF: MAG29P1

SINCLAIR C6 13" wheels complete with tube, tyre and cycle style bearing £6 ea REF: MAG6P10

AA NICAD PACK encapsulated pack of 8 AA nicad batteries (tagged) ex equip. 55x32x32mm. £3 a pack. REF: MAG3P11

13.8V 1.9A psu cased with leads. Just £9.99 REF: MAG10P3

360K 5.26 brand new half height floppy drives IBM compatible industry standard. Just £6.99 REF: MAG7P3

PPC MODEM CARDS These are high spec plug in cards made for the Amstrad laptop computers. 2400 baud data unit complete with leads. Clearance price is £5 REF: MAG5P1

INFRA RED REMOTE CONTROLLERS Originally made for hi spec satellite equipment but perfect for all sorts of remote control projects. Our clearance price is just £2 REF: MAG2

TOWERS INTERNATIONAL TRANSISTOR GUIDE. A very useful book for finding equivalent transistors, leadouts, specs etc. £20 REF: MAG20P1

SINCLAIR C6 MOTORS We have a few left without gearboxes. These are 12v DC 3,300 rpm 6"x4", 1/4" OP shaft. £25 REF: MAG25

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the above motor but suitable for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 REF: MAG17

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range (tune TV to a spare channel) 12v DC op. Price is £15 REF: MAG15 12v psu is £5 extra REF: MAG5P2

***FM CORDLESS MICROPHONE** Small hand held unit with a 500' range 2 transmit power levels. Reqs PP3 9v battery. Tuneable to any FM receiver. Price is £15 REF: MAG15P1

LOW COST WALKIE TALKIES Pair of battery operated units with a range of about 200'. Ideal for garden use or as an educational toy. Price is £8 a pair. REF: MAG8P1 2 x PP3 req'd.

***MINIATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range of up to 2 kilometres in open country. Units measure 22x52x155mm. Complete with cases and earpieces. 2xPP3 req'd. £30.00 pair. REF: MAG30.

COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £8.00 REF: MAG8P2.

LQ3600 PRINTER ASSEMBLIES Made by Amstrad they are entire mechanical printer assemblies including pinhead, stepper motors etc etc in fact everything bar the case and electronics, a good stripper! £5 REF: MAG5P3 or 2 for £8 REF: MAG8P3

SPEAKER WIRE Brown 2 core 100 foot hank £2 REF: MAG2P1

LED PACK of 100 standard red 5m leds £5 REF: MAG5P4

JUG KETTLE ELEMENT good general purpose heating element (about 2kw) ideal for heating projects. 2 for £3 REF: MAG3

UNIVERSAL PC POWER SUPPLY complete with flyleads, switch, fan etc. Two types available 150w at £15 REF: MAG15P2 (23x23x23mm) and 200w at £20 REF: MAG20P3 (23x23x23mm)

***FM TRANSMITTER** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever why pay £700? or price is £26 REF: MAG26 Transmits to any FM radio.

***FM BUG KIT** New design with PCB embedded coil for extra stability. Works to any FM radio. 9v battery req'd. £5 REF: MAG5P5

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

TALKING COINBOX STRIPPER originally made to retail at £79 each, these units are designed to convert and ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? Price is just £3 REF: MAG3P1

100 WATT MOSFET PAIR Same specs as 2SK343 and 2SJ413 (8A, 140v, 100w) 1 N channel, 1 P channel, £3 a pair REF: MAG3P2

VELCRO 1 metre length of each side 20mm wide (quick way of fixing for temporary jobs etc) £2 REF: MAG2P3

MAGNETIC AGITATORS Consisting of a cased mains motor with lead. The motor has two magnets fixed to a rotor that spin round inside. There are also 2 plastic covered magnets supplied. Made for remotely stirring liquids! you may have a use? £3 each REF: MAG3P3

BULL'S BULLETIN BOARD

**100MHZ DUAL TRACE
OSCILLOSCOPES
JUST £259
RING FOR DETAILS**

MASSIVE

**WAREHOUSE CLEARANCE
FANTASTIC £20.00 REDUCTION
REFURBISHED PC BASE UNITS
COMPLETE WITH KEYBOARD**

FROM ONLY **£29.00**

**AMSTRAD 1512 BASE UNITS
GUARANTEED
PERFECT WORKING ORDER.**

A LOW COST INTRODUCTION TO THE HOME COMPUTER MARKET.

AMSTRAD 1512SD

1512 BASE UNIT, 5.25" FLOPPY DRIVE AND
KEYBOARD. ALL YOU NEED IS A MONITOR AND
POWER SUPPLY. WAS £49.00

NOW ONLY **£29.00**

REF: MAG29

AMSTRAD 1512DD

1512 BASE UNIT AND KEYBOARD AND TWO
5.25" 360K DRIVES. ALL YOU NEED IS A MONITOR
AND POWER SUPPLY. WAS £59.00

NOW ONLY **£39.00**

REF: MAG39

SOLAR POWER PANELS

**3FT X 1FT 10WATT GLASS PANELS
14.5v/700mA
NOW AVAILABLE BY MAIL ORDER
£33.95**

(PLUS £2.00 SPECIAL PACKAGING CHARGE)

TOP QUALITY AMORPHOUS SILICON CELLS HAVE ALMOST A
TIMELESS LIFESPAN WITH AN INFINITE NUMBER OF POSSIBLE
APPLICATIONS, SOME OF WHICH MAY BE CAR BATTERY
CHARGING, FOR USE ON BOATS OR CARAVANS, OR ANY
WHERE A PORTABLE 12V SUPPLY IS REQUIRED. REF: MAG34

FREE SOFTWARE!

Brand new, **UNUSED** top quality *Famous brand*
licensed software discs. Available in 5.25" DSD or 5.25"
HD only. You buy the disk and it comes with free BRAND
NEW UNUSED SOFTWARE. We are actually selling you the
floppy disc for your own "MEGA CHEAP" storage facilities,
if you happen to get software that you want/need/like as
well..... you get a "MEGA BARGAIN" too!

DSD PKT10 £2.99 REF: MAG3P7 PKT100 £16.00 REF: MAG16

*****WE BUY SURPLUS STOCK*****

TURN YOUR SURPLUS STOCK INTO CASH.
IMMEDIATE SETTLEMENT. WE WILL ALSO QUOTE FOR
COMPLETE FACTORY CLEARANCE.

1994 CATALOGUE.

PLEASE SEND 45P, A4 SIZED SAE FOR YOUR FREE COPY.
MINIMUM GOODS ORDER £5.00 TRADE ORDERS FROM GOVERNMENT, SCHOOLS,
UNIVERSITIES & LOCAL AUTHORITIES WELCOME ALL GOODS SUPPLIED SUBJECT TO
OUR CONDITIONS OF SALE AND UNLESS OTHERWISE STATED GUARANTEED FOR 30
DAYS RIGHTS RESERVED TO CHANGE PRICES & SPECIFICATIONS WITHOUT PRIOR
NOTICE. ORDERS SUBJECT TO STOCK QUOTATIONS WILLINGLY GIVEN FOR QUANTI-
TIES HIGHER THAN THOSE STATED

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

BULL ELECTRICAL
250 PORTLAND ROAD HOVE SUSSEX
BN3 5QT

**MAIL ORDER TERMS: CASH PO OR CHEQUE
WITH ORDER PLUS £3.00 POST PLUS VAT.**

PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY

TELEPHONE ORDERS WELCOME

TEL: 0273 203500

FAX: 0273 323077



TOP QUALITY SPEAKERS Made for Hi Fi televisions
these are 10 watt 4R Jap made 4" round with large
shielded magnets. Good quality general purpose speaker.
£2 each REF: MAG2P4 or 4 for £6 REF: MAG8P2

TWEETERS 2" diameter good quality tweeter 140R (ok with the
above speaker) 2 for £2 REF: MAG2P5 or 4 for £3 REF: MAG3P4

AT KEYBOARDS Made by Apricot these quality keyboards need
just a small modification to run on any AT, they work perfectly but you
will have to put up with 1 or 2 foreign keycaps! Price £6 REF:
MAG8P3

XT KEYBOARDS Mixed types, some returns, some good, some
foreign etc but all good for spares! Price is £2 each REF: MAG2P8
or 4 for £6 REF: MAG8P4

PC CASES Again mixed types so you take a chance next one off
the pile £12 REF: MAG12 or two the same for £20 REF: MAG20P4

COMMODORE MICRODRIVE SYSTEM mini storage
device for C64's 4 times faster than disc drives, 10 times faster
than tapes. Complete unit just £12 REF: MAG12P1

SCHOOL STRIPPERS We have quite a few of the above
units which are 'returns' as they are quite comprehensive units
they could be used for other projects etc. Let us know how many you
need at just 50p a unit (minimum 10).

HEADPHONES 16P These are ex Virgin Atlantic. You can have
8 pairs for £2. REF: MAG2P8

PROXIMITY SENSORS These are small PCB's with what look
like a source and sensor LED on one end and lots of components on
the rest of the PCB. Complete with flyleads. Pack of 5 £3 REF: MAG:
3P5 or 20 for £8 REF: MAG8P4

SNOOPERS EAR? Original made to dip over the earpiece of
telephone to amplify the sound-it also works quite well on the cable
running along the wall! Price is £5 REF: MAG5P7

DOS PACKS Microsoft version 3.3 or higher complete with all
manuals or price just £5 REF: MAG5P8 Worth it just for the very
comprehensive manual! 5.25" only.

DOS PACK Microsoft version 5 Original software but no manu-
als hence only £3 REF: MAG3P6 5.25" only.

FOREIGN DOS 3.3-German, French, Italian etc £2 a pack with
manual. 5.25" only. REF: MAG2P9

CTM644 COLOUR MONITOR. Made to work with the CPC464
home computer. Standard RGB input so will work with other ma-
chines. Refurbished £59.00 REF: MAG59

PIR DETECTOR Made by famous UK alarm manufacturer these
are hi spec, long range internal units. 12v operation. Slight marks on
case and unboxed (although brand new) £8 REF: MAG8P5

WINDUP SOLAR POWERED RADIO AM/FM radio complete
with hand charger and solar panel! £14 REF: MAG14P1

COMMODORE 64 TAPE DRIVES Customer returns at £4
REF: MAG4P9 Fully tested and working units are £12 REF: MAG12P5

COMPUTER TERMINALS complete with screen, keyboard
and RS232 input/output. Ex equipment. Price is £27 REF: MAG27

MAINS CABLES These are 2 core standard black 2 metre mains
cables fitted with a 13A plug on one end, cable the other. Ideal for
projects, low cost manufacturing etc. Pack of 10 for £3 REF: MAG3P8

Pack of 100 £20 REF: MAG20P5

SURFACEMOUNT STRIPPER Originally made as some form
of high frequency amplifier (main chip is a TS45511T 1.3GHz
synthesiser) but good stripper value, an excellent way to play with
surface mount components £1.00 REF: MAG1P1

MICROWAVE TIMER Electronic timer with relay output suitable
to make enlarger timer etc £4 REF: MAG4P4

MOBILE CAR PHONE £5.99 Well almost! complete in car
phone excluding the box of electronics normally hidden under seat.
Can be made to illuminate with 12v also has built in light sensor so
display only illuminates when dark. Totally convincing! REF: MAG8P6

ALARM BEACONS Zenon strobe made to mount on an external
bell box but could be used for caravans etc. 12v operation. Just
connect up and it flashes regularly! £5 REF: MAG5P11

FIRE ALARM CONTROL PANEL High quality metal cased
alarm panel 350x165x80mm. With key. Comes with electronics but
no information. sale price 7.99 REF: MAG8P6

SUPER SIZE HEATSINK Superb quality aluminium heatsink.
365 x 183 x 81mm, 15 fins enable high heat dissipation. No holes!
sale price £5.99 REF: MAG6P11

REMOTE CONTROL PCB These are receiver boards for
garage door opening systems. You may have another use? £4 ea
REF: MAG4P5

6"x12" AMORPHOUS SOLAR PANEL 12v 155x310mm
130mA. Bargain price just £5.99 ea REF: MAG6P12

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99
ref: MAG5P13 ideal for experimenters! 30 m for £12.99 ref: MAG13P1

LOPTX Line output transformers believed to be for hi res colour
monitors but useful for getting high voltages from low ones! £2 each
REF: MAG2P12 bumper pack of 10 for £12 REF: MAG12P3.

**SHOP OPEN 9-5.30 SIX
DAYS A WEEK**

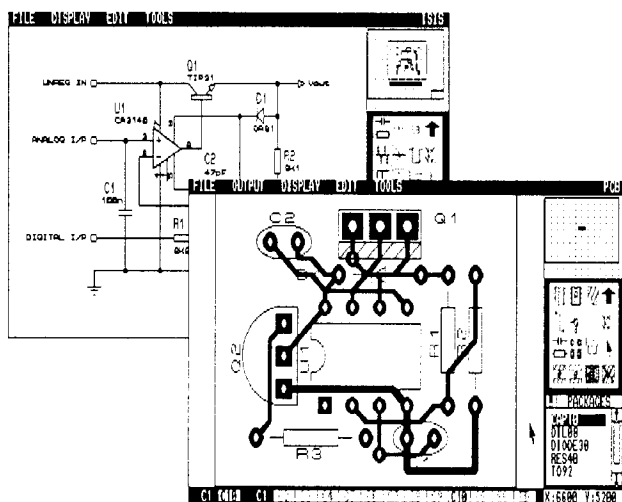
**PORTABLE RADIATION DETECTOR
£49.99**

A Hand held personal Gamma and X Ray detec-
tor. This unit contains two Geiger Tubes, has a 4
digit LCD display with a Piezo speaker, giving an
audio visual indication. The unit detects high
energy electromagnetic quanta with an energy
from 30K eV to over 1.2M eV and a measuring
range of 5-9999 UR/h or 10-99990 Nr/h. Supplied
complete with handbook.

REF: MAG50

POWERFUL SCHEMATIC CAPTURE, PCB DESIGN AND AUTOROUTING ALL FOR JUST £395...

PROPAK AR provides all the features you need to create complex PCB designs quickly and easily. Draw the circuit diagram using the powerful facilities of ISIS DESIGNER+ and then netlist into ARES AUTOROUTE for placement, autorouting and tidy up. Advanced real time design rule checks guarantee that the final PCB will correspond exactly with the schematic thus saving you from costly layout errors and time consuming debugging.



- Attractive, easy to use graphical interface.
- Object oriented schematic editor with automatic wire routing, dot placement and mouse driven place/edit/move/delete.
- Netlist generation for most popular CAD software.
- Bill of Materials and Electrical Rules Check reports.
- Two schemes for hierarchical design.
- Automatic component annotation and packaging.
- Comprehensive device libraries and package libraries including both through hole and SMT parts.
- User definable snap grids (imperial and metric) and Real Time Snap to deal with tricky SMT spacings.
- Manual route editing features include Auto Track Necking, Topological editing and Curved tracks.
- Autorouting for single, double and multi-layer boards.
- Non autorouting PROPAK is available for just £250 if you do not need or want the router.
- Full connectivity and design rule checking.
- Power plane generator with thermal relief necking.
- Graphics support to 800x600 Super VGA.
- Output to dot matrix and laser printers, HP and Houston plotters, Postscript devices, Gerber and Excellon NC machines plus DXF and other DTP file formats.

CADPAK

Two Programs for the Price of One

ISIS SUPERSKETCH

A superb schematic drawing program for DOS offering Wire Autorouting, Auto Dot Placement, full component libraries, export to DTP and much more.

**Only
£79**

Exceptionally easy and quick to use. For example, you can place a wire with just two mouse clicks - the wire autorouter does the rest.

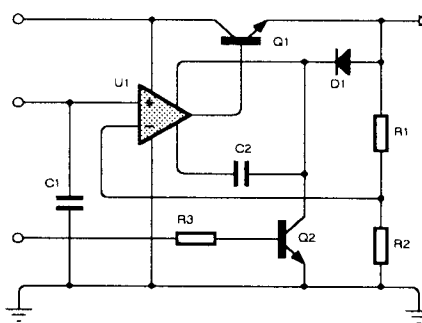
PCB II

High performance yet easy to use manual PCB layout package. Many advanced features including curved tracks, auto track necking, DXF export, Gerber and NC file generation, Gerber viewing and more.

Alan Chadwick writing in ETI (January 94) concluded...
"At £79 I thought this was an excellent buy."

ISIS ILLUSTRATOR

Schematic Drawing for Windows



**From
£99**

Running under Windows 3.1, ISIS ILLUSTRATOR lets you create presentation quality schematic drawings like you see in the magazines. Furthermore, when the drawing is done, transferring it to another document is just a matter of pasting it through the Clipboard.

Now used by a number of prominent technical authors to illustrate their latest books and magazine articles.

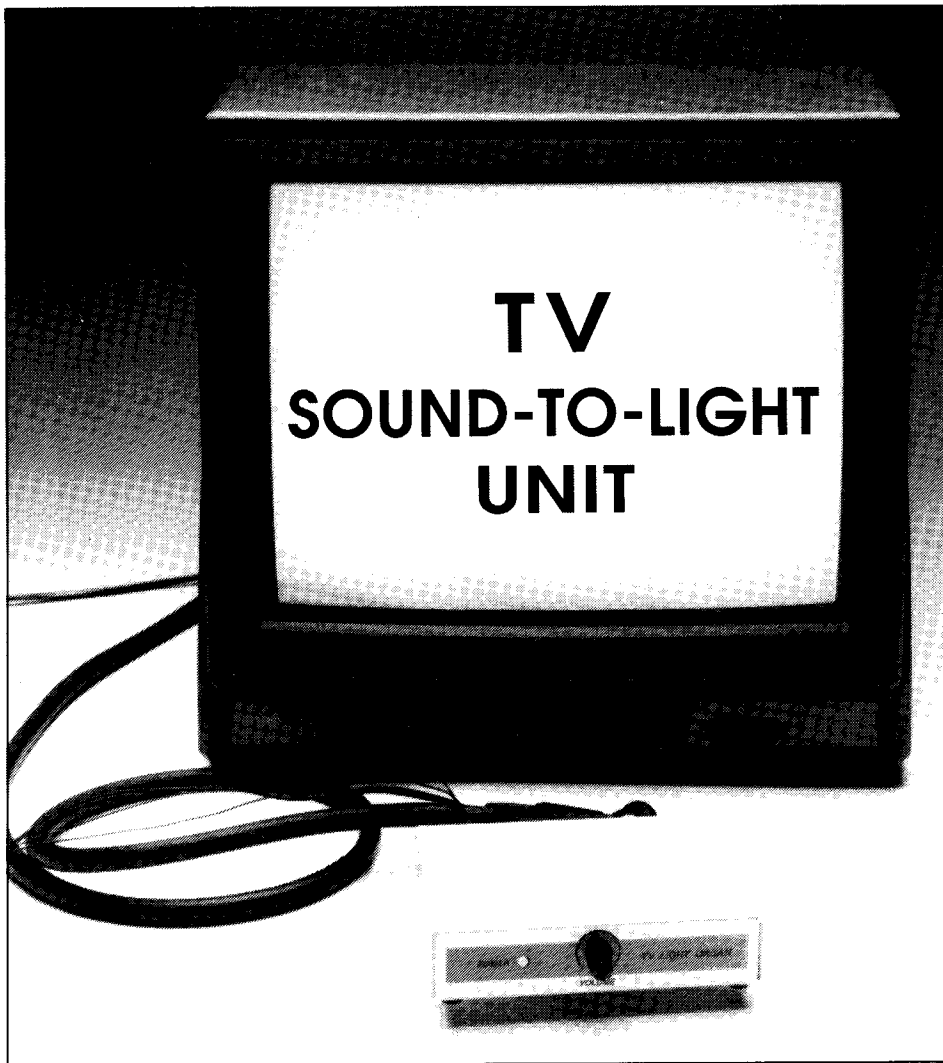
Labcenter
Electronics



Call us today on 0274 542868 or
fax 0274 481078 for a demo pack -
state DOS or Windows. Multi-copy and
educational discounts available.

Prices exclude p&p (£5 for U.K.) and VAT. All manufacturers' trademarks acknowledged.

14 Mariner's Drive, Bradford, BD9 4JT.



Although huge monitors are quite common in today's party bunkers, clubs and discotheques, the idea of using a TV set instead of the more usual set of coloured lamps is quite novel. Here, a circuit is described to produce playful light effects on the telly.

From an idea by B. Willaert

THE TV sound-to light unit described in this article may be driven with a line signal or a signal picked up by a microphone. Depending on the spectral composition of the input signal (bass, mid-range, treble), the circuit sends a signal to the red, green or blue (R, G, B) input on the SCART socket of a TV set. This causes the TV screen to go red, green or blue, or blends of these primary colours if the input signal contains two or three strong components in the respective frequency ranges. This means that the operation of the TV sound-to-light unit is, in principle, identical to that of a 'conventional' unit with three lamps. As an unusual feature, however, the present unit enables colours to be mixed.

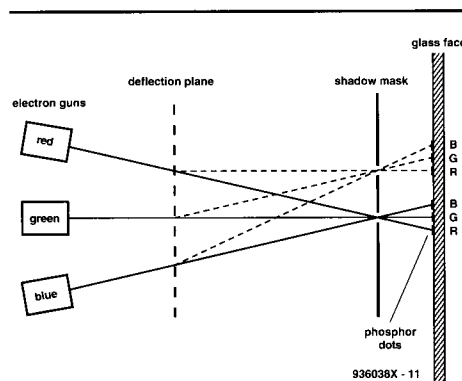


Fig. 1. The perceived colour of a picture element is created by blending the primary colours, red, green and blue, at the right ratio. The correct colour is obtained by firing electrons at phosphor particles at the inside of the picture tube.

Television: the basics

Before looking at the design of the TV sound-to-light unit, a brief recap is given of the operation of the TV system. The screen of a colour TV may be compared with a painter's palette with only the three primary colours on it: red (R), green (G) and blue (B). Any colour can be made by mixing the RGB components at certain ratios.

A TV set obviously does not use paint to mix colours. Instead, the primary colours are mixed using electron beams. The principle is illustrated in Fig. 1. Each primary colour has its own electron gun which 'fires' a very narrow beam in the direction of the inside surface of the TV picture. The three beams converge at the so-called shadow mask at the inside of the picture tube. The mask is a thin plate with masses of small holes which pass the three beams. When the beams leave the holes in the shadow mask, they arrive on a layer of phosphor particles which covers the inside of the picture tube. Each beam 'hits' its own phosphor type. The phosphor particles light up when 'bombarded' with electrons, and so visualize the colours red, green and blue.

Since the three tiny light spots in each pixel are very close together, the viewer perceives a dot with a certain colour blend rather than three individual primary colours. In this way, each picture element ('pixel') is provided with the correct colour information, and the entire picture is built up pixel-by-pixel.

The received TV signal contains, among others, information on the mixture ratio of the R, G and B signals. This information is received in compacted form, and decoded inside the TV set to yield the three primary colours. Most modern TV sets have a SCART socket (also called Peritel or Euro A/V), which allows the RGB amplifiers and associated electron guns in the set to be driven with external signals. And that, you guessed it, is exactly what the present circuit does.

Block diagram

The basic structure of the TV sound-to-light unit is shown in Fig. 2. As with an 'ordinary' sound-to-light unit, the input signal is obtained either from a 'line' connection (say, the mixing console output) or a microphone. The sensitivity of the circuit is adjustable by setting the gain of the input amplifier.

The amplified audio signal is fed to three filter sections: a low-pass filter, a band-pass filter and a high-pass filter. These filters extract the bass, mid-range and treble information from the input signal. The filter output signals

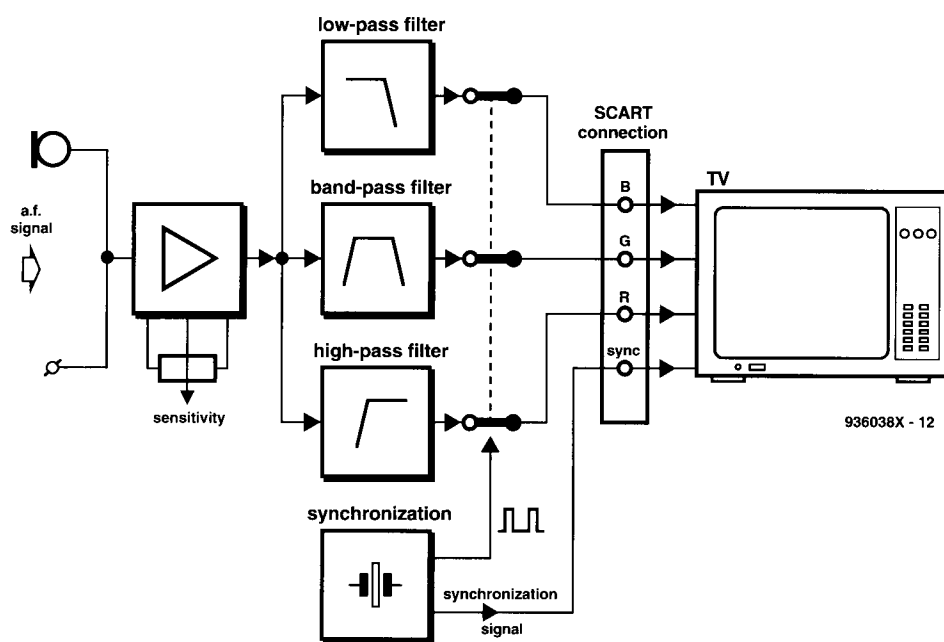


Fig. 2. Most functions of the TV sound-to-light unit may be found in any conventional sound-to-light unit based on lamps. The difference, however, is the TV interface, which consists of RGB driver stages and a synchronisation control circuit.

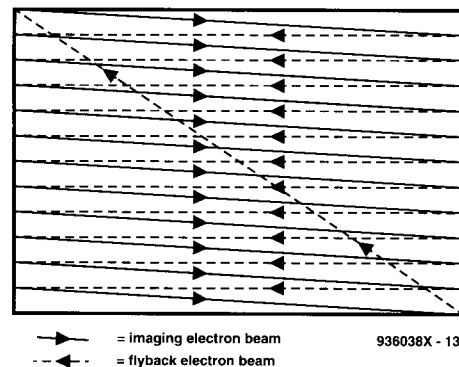


Fig. 3. The flyback (retrace) beam is quenched to avoid unwanted horizontal and diagonal lines on the TV screen.

then drive the RGB inputs of the TV. Low frequencies cause the screen to go red, while mid-range and high components turn it green or blue respectively.

The block diagram also shows a synchronisation sub-circuit. This serves to ensure that every picture line has the right length (approx. 64 μ s), and that the retrace (or 'flyback') beam is

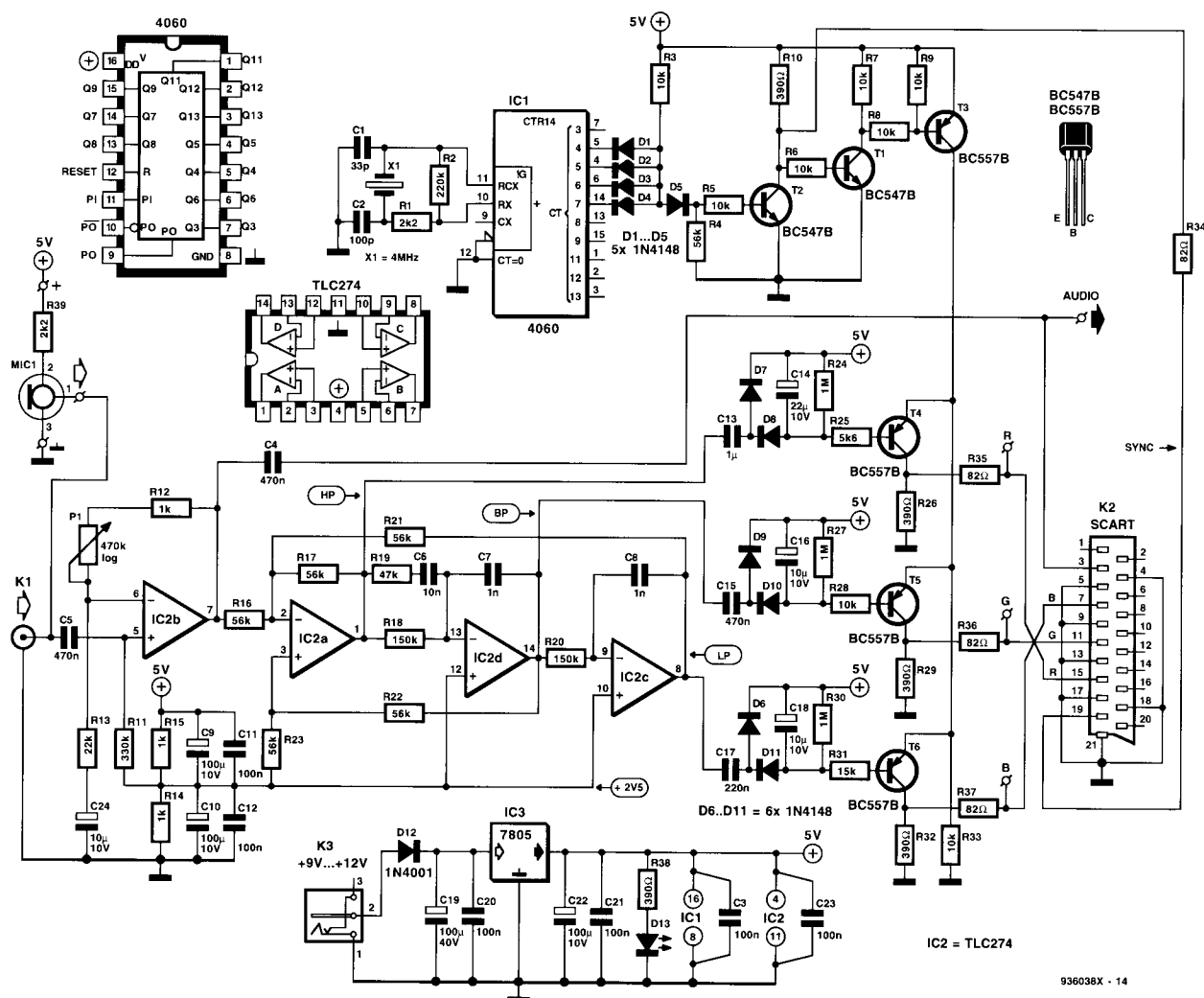


Fig. 4. Circuit diagram of the TV sound-to-light unit. The circuit takes its input signal either from a microphone or a line connection. A crystal oscillator is used to ensure the correct picture line length of 64 μ s (including the synchronisation pulse).

quenched. As illustrated in **Fig. 3**, the electron beam makes a scanning movement across the screen. During the retrace period, the beam is quenched (switched off) to avoid unwanted lines, both horizontally and diagonally, being written on to the screen.

Practical circuit

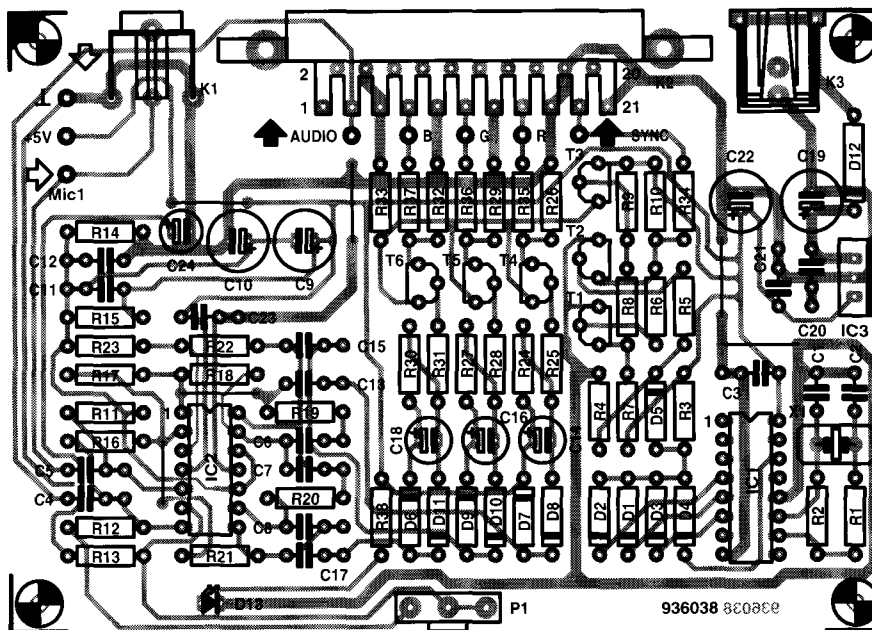
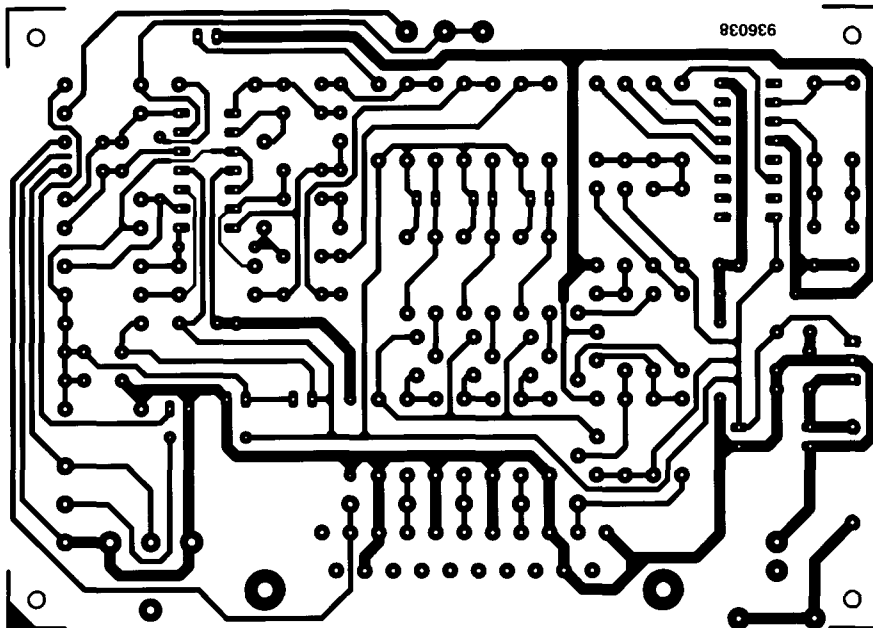
Although the circuit diagram in **Fig. 4**

looks complex at first glance, the functions of the various sub-circuits are easily recognized from the block diagram discussed above.

The audio signal is picked up by microphone Mic_1 , and fed to the input of a simple preamplifier stage based on opamp IC_{2b} . Alternatively, the input signal may be applied directly via 'line' socket K_1 . The amplification of IC_{2b} may be set to a value between 0.02 and

20. The preamplifier output signal is applied to a combined filter, which divides the signal into low, mid-range and high components. The high frequencies leave the filter via pin 1 of IC_{2a} . The mid-range signals are found at pin 14 of IC_{2d} , and the low frequencies, at pin 8 of IC_{2c} .

Next, the three components are applied to three identical drivers, T_4 , T_5 and T_6 . Each signal is first rectified



COMPONENTS LIST

Resistors:

R1;R39 = 2k Ω
 R2 = 220k Ω
 R3,R5-R9,R28,R33 = 10k Ω
 R4,R16,R17,R21,R22,R23 = 56k Ω
 R10,R26,R29,R32,R38 = 390 Ω
 R11 = 330k Ω
 R12,R14,R15 = 1k Ω
 R13 = 22k Ω
 R18,R20 = 150k Ω
 R19 = 47k Ω
 R24,R27,R30 = 1M Ω
 R25 = 5k Ω
 R31 = 15k Ω
 R34-R37 = 82 Ω
 P1 = 470k Ω logarithmic

Capacitors:

C1 = 33pF
 C2 = 100pF
 C3,C11,C12,C20,C21,C23 = 100nF
 C4,C5,C15 = 470nF
 C6 = 10nF
 C7,C8 = 1nF
 C9,C10,C22 = 100 μ F 10V radial
 C13 = 1 μ F MKT
 C14 = 22 μ F 10V radial
 C16,C18,C24 = 10 μ F 10V radial
 C17 = 220nF
 C19 = 100 μ F 40V radial

Semiconductors:

D1-D11 = 1N4148
 D12 = 1N4001
 D13 = LED 3mm red
 T1,T2 = BC547B
 T3-T6 = BC557B
 IC1 = 4060
 IC2 = TLC274
 IC3 = 7805

Semiconductors:

K1 = Cinch socket.
 K2 = 21-way SCART socket, PCB mount, angled pins.
 K3 = Mains adapter socket, PCB mount.
 X1 = 4MHz quartz crystal.
 Mic1 = Electret microphone.
 Case: e.g., ESM EM14/03.
 Printed circuit board 936038 (see page 70).

Fig. 5. Track layout (direct reading) and component overlay of the circuit board for the TV sound-to-light unit (PCB available ready-made through the Readers Services).

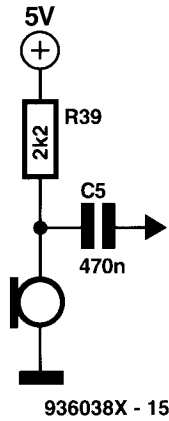


Fig. 6. Alternative connection schematic for two-wire electret microphones.

and smoothed by two diodes and a capacitor (for instance, D₇, D₈ and C₁₄), so that each driver is supplied with a clean direct voltage. The resistor across each smoothing capacitor (for instance, R₂₄) enables the capacitor voltage to decrease after a short while after the input signal has disappeared. This is done to give the sound-to-light unit a fairly 'calm' behaviour, avoiding a too fast response to sound changes. The output signal of each driver transistor is sent to the respective RGB input via a current limiting resistor of 82 Ω.

The circuit diagram shows that the RGB driver transistors are supplied via a series transistor, T₃, which acts as a switch, and so enables a simple kind of synchronisation to be realized. The switch is closed for 60 μs, which corresponds to the length of a picture line. Each period of 60 μs is headed by a synchronisation pulse of 4 μs, which serves to inform the TV that a new line is about to be written. The synchronisation pulse is sent to the TV set via R₃₄ and the respective pin on the SCART socket. To make sure that each line period has a total length of 64 μs, the switching signals are derived from a crystal oscillator with associated divider, IC₁. The 4-MHz quartz clock signal is divided by 256 (2⁸), which gives a line frequency of 15.625 Hz, corresponding to a period of 64 μs.

Finally, the circuit is powered by a mains adaptor with a direct output voltage between 9 V and 12 V. The adaptor output voltage is stepped down to 5 V by regulator IC₃.

Construction

The artwork of the printed circuit board designed for the TV sound-to-light unit is given in Fig. 5. This board is available ready-made through the Readers Services.

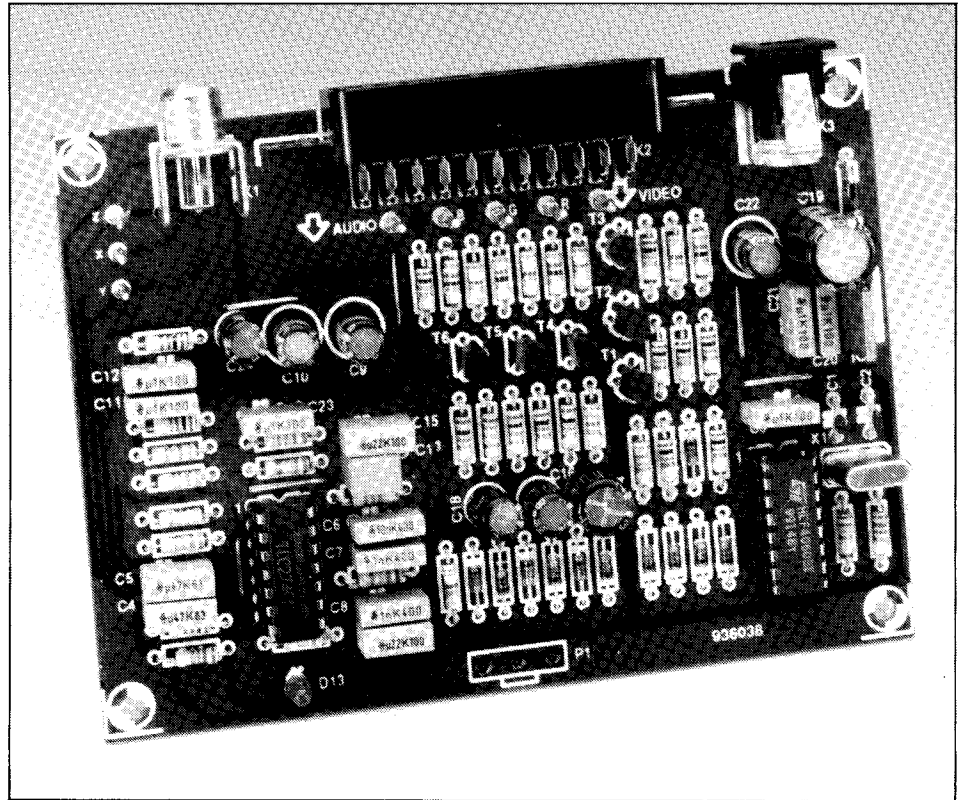


Fig. 7. Fully populated circuit board.

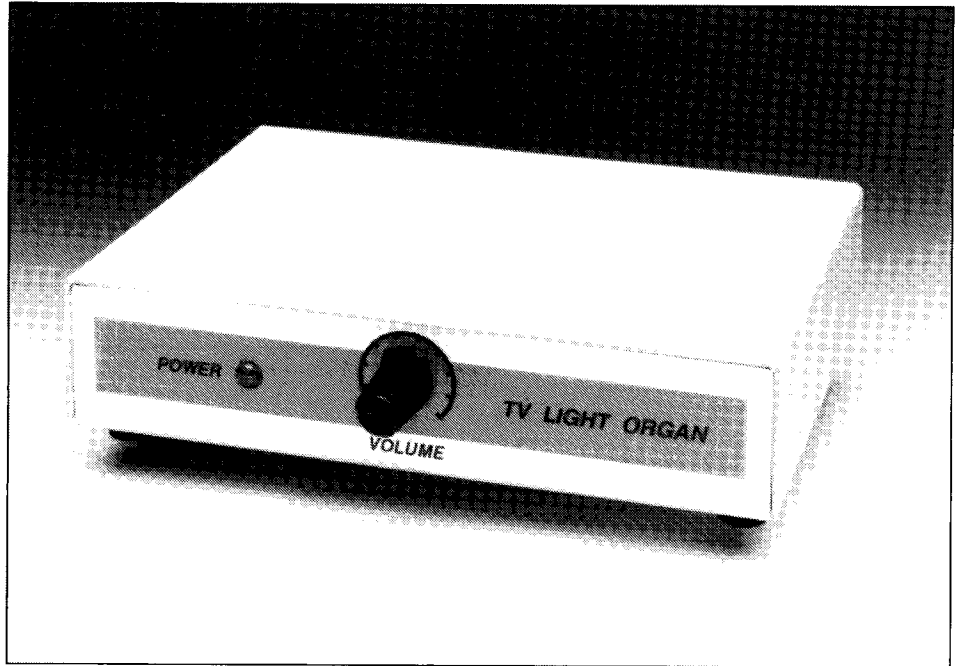


Fig. 8. Prototype of the TV sound-to-light unit mounted into a plastic enclosure.

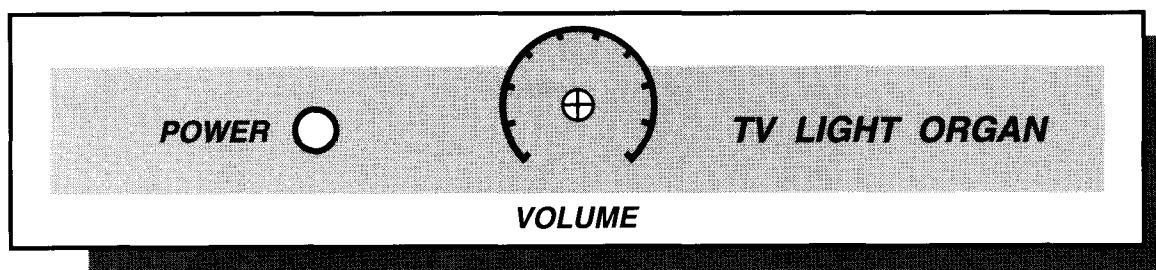
Start the construction by fitting all wire links, then the IC sockets. Solder carefully to avoid a long fault-finding session later. Next, fit all other parts, keeping the larger ones (for instance, the SCART socket and potentiometer P₁) till the last. The SCART socket is first secured to the PCB by inserting its plastic fixing pins into the two holes in the PCB. Next, solder the socket pins.

Resistor R₃₉ is not fitted on to the board, but connected to the electret microphone as a 'flying' part. If the microphone is a type with three terminals, it is connected as shown by the

circuit diagram. If you happen to have a two-terminal type, connect it as shown in Fig. 6. If you wish to use the line input only, Mic₁ and R₃₉ may, of course, be omitted.

The board is ready for fitting into a suitable enclosure after it has been populated (Fig. 7), and the solder work carefully inspected. The prototype shown in Fig. 8 should give you an impression of how we did the finishing touch to the unit. The design of a front panel for the TV sound-to-light unit may be copied from Fig. 9.

Connect the unit to the mains adap-



936038X - F

Fig. 9. Suggested front panel design.

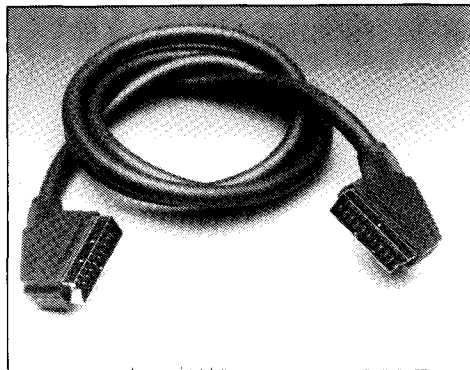


Fig. 10. The sound-to-light unit is connected to the TV set via a ready-made SCART cable.

tor, taking good care to observe the polarity of the d.c. supply voltage. The circuit is protected against reverse supply voltages by diode D_{12} . If everything is in order, the 'power' LED should light after connecting the mains

adaptor.

Next, connect the circuit to the TV set via ready-made SCART cable (Fig. 10). The pinning of the SCART plugs on the cable, and that of the socket on the TV, is shown in Fig. 11. Also connect the microphone, or the line input signal.

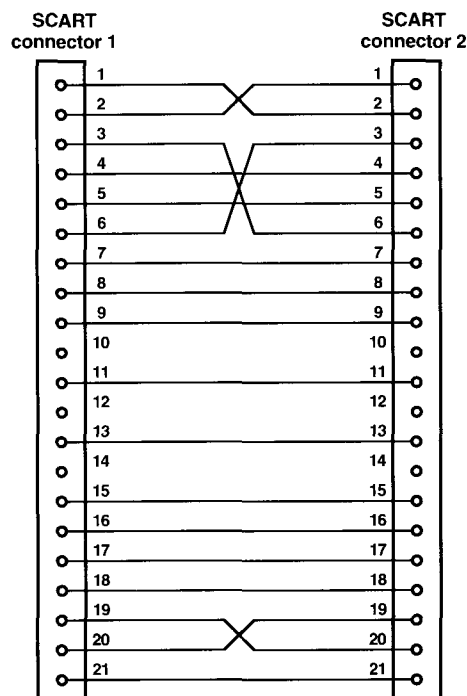
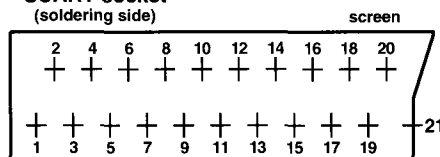
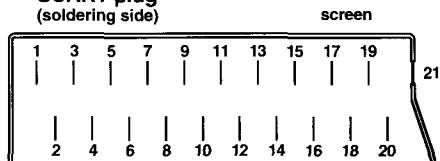
Switch the TV to external A/V, and adjust the input sensitivity of the sound-to-light unit until the desired visual effect is achieved.

Some experiments

A few suggestions are given for those of you who wish to adapt the circuit to personal requirements. The response of the circuit to changes in the input signal may be speeded up by decreasing the values of capacitors C_{14} , C_{16} and C_{18} . Note, however, that this causes a slightly blurred picture, and

unclear colour transitions. Similarly, the response of the circuit is slowed down by increasing the values of the above capacitors.

The 'low' frequency limit of the filter in the unit may be lowered by changing R_{18} and R_{20} into, for instance, 220 k Ω , and R_{19} into 100 k Ω . This modification causes the circuit to respond stronger to the lowest frequency components, and less to high-frequency components. To achieve a better separation of the low, middle and high components, the value of R_{19} may be lowered to 22 k Ω , while C_6 is changed into 22 nF.

SCART socket
(soldering side)SCART plug
(soldering side)

936038X - 16

Fig. 11. Want to make a SCART cable yourself? Here are the plug and socket connections.

ELECTRONICS SCENE

Surface mount crystal from IQD

International Quartz Devices (IQD) has available a surface mount version of the popular HC49/4H crystal. Designated the HC49/4HSMX, the new version has a footprint of only 4.9x13.4 mm and is 4.3 mm high.

IQD Ltd, Crewkerne, Somerset TA18 7AR, England. Telephone (0460) 77155.

Embedded controller handbook

Microchip's new *Embedded Controller Handbook* is packed with ideas and advice for system designers and application programmers. It contains almost a thousand pages of technical reference material and covers the whole range of Microchip's PIC16/17 8-bit microcontrollers and speciality non-volatile memory products.

Arizona Microchip Technology Ltd, Unit 3, The Courtyard, Meadowbank, Furlong Road, Bourne End SL8 5AJ, England. Telephone (0628) 850 303.

Statek franchise for ACT

Quartz crystal manufacturer and distributor ACT (Advanced Crystal Technology) has signed a franchise agreement with the specialist quartz crystal firm, Statek Inc. of Orange, California.

ACT, 9 Kingfisher Court, Hambridge Road, Newbury RG14 5SJ, England. Telephone (0635) 528 520.

Good for Europe?

The Japanese government is about to abandon Japan's analogue high-definition television system, which lags behind America's digital technology despite decades of development. This decision makes it probable that a **worldwide HDTV standard** based on America's may at last emerge. If so, a sigh of relief will be heard in the larger part of the world—particularly in the corridors of Thomson and Philips, both members of the US association of HDTV manufacturers.

Nevertheless, Europe will lose out on some aspects, because, although both the US and Europe have chosen MPEG compression, the US has opted for vestigial sideband (VSB). The European 'standard' for digital TV is quadrature amplitude modulation. However, this should not matter much since the European mass market for HDTV equipment is not likely to come about until the early part of the next century.

Apple at the top

Dataquest, the influential US analyst firm, has announced that Apple Computer Inc. was the largest PC maker in the USA in 1993, just ahead of rivals IBM and Compaq. Apple gained 14.1% of the market, IBM 13.9% and Compaq 10%.

Eighth North Wales

Radio & Electronics Show

The Eighth North Wales R&E Show will be held on 5 and 6 November 1994 at the Aberconwy Conference Centre & The New Theatre, Llandudno. The Show opens at 10.00 a.m. both days. Entrance fee £ 1.50; under the age of 14 admission is FREE.

North Wales Radio Rally Club, Annecott, Hylas Lane, Rhuddlan, Clwyd LL18 5AG. Telephone/fax (0745) 591 704.

Emulation support for embedded 80386CX/EX

German in-circuit emulator manufacturer Hitex (see advert on p. 36) have announced the first full in-circuit emulators for the new Intel 80386CX/EX embedded microprocessors. Using the existing PC-based T32/386SX emulator as a base, the CX version allows true in-circuit emulation of the CPU up to 20 MHz (25 MHz to special order) in both 100PQFP and MQFP packages.

A comprehensive information pack is available from Hitex covering all 80386 family development tools.

Hitex (UK) Ltd, Sir William Lyons Road, Science Park, Coventry CV4 7EZ, England. Telephone (0203) 692 066.

SpiceAge 3 for Windows

V3 of SpiceAge for Windows gives an order of magnitude of speed rise for logic simulation over SpiceAge 2, previously believed to be the fastest analogue simulator of its type available. V3 benchmarks at 9 s on the digital test compared with 120 s on V2. Speed gains are also apparent on some analogue circuits.

To support this, a new 32-channel logic analyser display is available, more digital models are provided and input signal bus structures are supported. The Zetex SPICE library of analogue semiconductor models is shipped with V3 and the analogue side is further expanded by a brand new operational amplifier especially developed to exploit the linear extrapolation pragmas provided in SpiceAge's polynomial functions. Not only is this topology more accurate than many SPICE models but is faster to analyse. **Those Engineers Ltd, 31 Birkbeck Road, London NW7 4BP, England. Telephone 081 906 0155.** (See also advert on p. 59).

New autorouter from ULTImate

ULTImate's new Ripup & Retry Autorouter, the ULTIroute GXR, a Windows-based product, is a sophisticated autorouter offering very high completion rates whilst remaining user interactive and friendly. ULTIroute GXR gives the user control over cost factors and strategies, allowing him to influence the behaviour of the router and therefore customise the router to his type of designs.

There are also new versions (4.50) of ULTIboard and (1.50) ULTIcap. Both are now 32 bit using a Windows compliant DOS extender.

ULTIboard, the first PCB design package to benefit from Real Time Design rule checking has been enhanced with powerful Trace Shove and Polygon features.

ULTIcap offers several powerful automatic features that reduce editing time, including Autowire, Auto Snap to Pin, Auto Junction and Real Time Electrical Rule Checking.

ULTImate Technology (UK) Ltd, 2 Bacchus House, Calleva Park, Aldermaston RG7 4QW, England. Telephone (0734) 812 030. (See inside front cover).

New from Maplin

A combined **clock and thermometer**, with an outdoor temperature probe, that can display either °C or °F. The LCD alternates between time and temperature readings at three second intervals. The unit, type-coded BU77J, measures 68x52x16 mm, and is priced at £ 9.95 (incl. VAT).

A range of **high power speakers**, specially designed for use in cars. Power rating from 50 W to 200 W. Prices range from £ 34.95 to £ 149.95 each (incl. VAT).

The **Fox Wireless Home Alarm** has been specially designed to help protect the home or office without spoiling the decoration with yards of ugly wiring. Because there is no wiring between the intrusion detectors and the control panel, the system can be easily installed by anyone with average DIY skills. Price £ 99.99 (incl. VAT).

The **Auto-inflating digital blood pressure monitor** is an easy to use, digital, blood pressure tester designed to remove the complexities of measuring blood pressure and pulse rate, particularly for those who are not familiar with the technique. Price £ 74.95 (incl. VAT). **Maplin Electronics, P.O. Box 3, Rayleigh SS6 8LR, England. Phone (0702) 552 911.**

Z-Match for Windows

The paper Smith Chart, invented over 50 years ago provides a graphical method for solving impedance matching and transmission line problems. Number One Systems' new Z-Match for Windows program greatly enhances the usefulness and accuracy of Smith Chart techniques, and adds a wide range of valuable Radio Frequency Engineering utilities.

An immediately apparent advantage of Z-Match for Windows is that it works directly with actual lengths of transmission line and actual resistance and reactance values, eliminating the need for normalisation.

Z-Match for Windows displays impedance values produced by Analyser III, Number One Systems' simulation tool for analogue circuits. In combination, these packages cover the vast majority of design and analysis problems likely to be faced by engineers and students working at RF.

Number One Systems, Harding Way, St. Ives, Huntingdon, England. Telephone (0480) 461 778. (See also p. 4)

LETTERS

Dear Editor—I have found that the BFX36 used in the '100 W high-end power amplifier' (March 1994) is no longer available. In fact, I was told that production of this device was discontinued in 1991. This does not seem in line with your recently stated policy of trying to only publish designs for which the components are actually available. Would the designer please give advice on component values for the amplifier input stage using more readily available transistors, such as the ZTX851, ZTX951. I appreciate that the amplifier performance may not be quite as good with discrete transistors, but it would at least allow the design to be built. I have built a number of your projects in the past which I have always found to be very good and I find it annoying that I cannot build this amplifier to go with them.

Simon Platt, Bedford

We are aware of the problems regarding availability of the BFX36. Although the device is obsolescent, stocks are still available here and there, more particularly from one of our advertisers, C-I Electronics, P.O. Box 22089, 6360 AB Nuth, the Netherlands. Fax +31 45 241 877. In fact, the BFX36 and its complement, the 2N2914, are listed in C-I's advert on p. 33 of our March 1994 issue.

Our Central Design Department are examining the specifications of several possible replacements for the BFX36/2N2914. When suitable types have been found, the relevant update information will be published in this magazine.

Dear Editor—I have just completed the construction of the 'Digital dial' described in the January 1994 issue. May I relate some quite interesting matters that arose during construction and testing?

My mistake (discovered after two days) was to use a 74HC4060 instead of the specified 4060. I only did this because I happened to have the 74 version and not a 4060. It does not work! I don't know why. They are supposed to be compatible. After the change,

the 'dial' worked really well.

I have fitted it to my AR88LF. The display is fitted behind the 'window' on the front panel which should contain an 'S' meter. The rest is in a box resting on the IF transformers. I tried to use the 6.3 V heater supply, as that is available at the dial light, but I could not get a suitable transformer. In the end, I put a mains transformer in the box with the rest of the components.

If any of your readers have in mind making a 'Digital Dial' for their AR88, I can let them have details of an easy way of obtaining the LO feed without any soldering or up-ending the receiver (which must weigh a good 25 kg).

One feature of the 'dial' I should mention is that the three horizontal bars of the first digit in the display do not attain full brilliance. Perhaps this is due to all being fed from the same pin of the 4543? No great disadvantage, but can this be overcome?

On a completely different tack, I was asked the other day what SCART stood for. I do not know – do you? Is it an acronym or what is it (apart from a standard socket for computers)?

C.E.H. Benson, Warrington.

Thanks for your letter, which we feel sure will be of interest to many other readers.

The matter of the brilliance of the first three horizontal bars has been referred to the designer. As soon as his answer is to hand, we will write to you.

SCART is an acronym of Syndicat des Constructeurs d'Appareils Radiorécepteurs et Téléviseurs, the French association of radio and television manufacturers. This association decided in the early 1980s to terminate various inputs to, and outputs from, TV receivers into a 21-way socket, which has since become a European standard.

Dear Editor—I read with interest your article on the SCMS inhibitor for DAT machines (Copybit Eliminator – February 1994). I would like to make this unit for use between two Sony Portable DATs, i.e., the D3 and D7 machines. A separate box would be required with either coax or fibre optic connectors.

less otherwise specified.

The direct working voltage of capacitors (other than electrolytic or tantalum types) is assumed to be ≥ 60 V. As a rule of thumb, a safe value is about $2\times$ direct supply voltage.

Direct test voltages are measured with a $20\text{ k}\Omega/\text{V}$ meter unless otherwise specified.

Mains (power line) voltages are not listed in the articles. It is assumed that our readers know what voltage is standard in their part of the world.

Readers in countries that use 60 Hz supplies, should note that our circuits are usually designed for 50 Hz. This will not normally cause problems, although if the mains frequency is used for synchronization, some modification may

I am a musician, not a technical person, but I can use a soldering iron, so any help you can give me would be gratefully appreciated. I presume any components required can be purchased from Maplin or any other such supplier.

G. Drucquer, Frimley Green.

We are currently working on a stand-alone version, i.e., one that can be inserted between two DAT recorders as you require. We plan to publish the relevant article in our July/August 1994 issue. Briefly, the design will consist of the 'Digital audio enhancer' (February 1993) in slightly modified form, the 'Copybit eliminator', and a small add-on board. All this is, however, tentative and will depend on the tests our design department are currently carrying out proving successful.

Dear Editor—I have sent for the PIC programmer project that appeared in the March 1994 issue of your magazine and in the article eight $499\text{ k}\Omega$ 1% resistors are needed. I have looked in various catalogues and TV and electronics magazines and I cannot find a source for such components. Please could you tell me where I could find them.

Why didn't you use presets or if these were not accurate enough, why didn't you use multiturn presets.

Have you ever considered having full kits (incl. all components) for your projects.

M. McCabe, Redcar

Precision 1%, and even 0.1%, resistors are available from specialist audio/hi-fi component retailers. You may, for instance, try Viewcom—see pages 8 & 9 of our March and April 1994 issues. Complete kits are available from C-I Electronics—see the advert on p.33 of our April 1994 issue.

Presets cannot be expected to give anywhere near the same performance as precision resistors, but we have, nevertheless, passed your query to the designer.

As international book/magazine publishers, we cannot go into the specialist electronics trade, but leave this to the experts: our advertisers and other electronic component retailers.

be required.

The international letter symbol 'U' is used for voltage instead of the ambiguous 'V'. The letter V is reserved for 'volts'.

The size of a metric bolt or screw is defined by the letter M followed by a number corresponding to the overall diameter of the thread in mm, the $\times$ sign and the length of the bolt or screw, also in mm. For instance, an M4 $\times$ 6 bolt has a thread diameter of 4 mm and a length of 6 mm. The overall diameter of the thread in the BA sizes is: 0 BA = 6.12 mm; 2 BA = 4.78 mm; 4 BA = 3.68 mm; 6 BA = 2.85 mm; 8 BA = 2.25 mm.

COMPONENT RATINGS

In resistor and capacitor values, decimal points and large numbers of zeros are avoided wherever possible. Small and large values are usually abbreviated as follows:

p (pico-)	= 10^{-12}
n (nano-)	= 10^{-9}
μ (micro-)	= 10^{-6}
m (milli-)	= 10^{-3}
k (kilo-)	= 10^3
M (mega-)	= 10^6
G (giga-)	= 10^9

Note that nano-farad (nF) is the international way of writing 1000 pF or 0.001 μF . Resistors are $\frac{1}{3}$ watt, 5% metal film types un-

READERS SERVICES

Except in the USA and Canada, all orders, except for subscriptions and past issues (for which see below), must be sent BY POST to our Dorchester office using the appropriate form opposite. Please note that we can not deal with PERSONAL CALLERS, as no stock is carried at the editorial and administrative office.

Readers in the USA and Canada should send orders, except for subscriptions (for which see below), to Old Colony Sound Lab, Peterborough, whose full address is given on the order form opposite. Please include shipping cost according to total order value. For surface delivery in the USA, if order is less than \$50, include \$3; \$50+, \$4. For Canada surface, if less than US\$50, include US\$5; US\$50+, US\$7.50. For air or other deliveries, please inquire. Please allow 4-6 weeks for delivery.

All other customers must add postage and packing charges for orders up to £25.00 as follows: UK and Eire £1.95; surface mail outside UK £2.45; Europe (airmail) £2.95; outside Europe (airmail) £3.70. For orders over £25.00, but not exceeding £100.00, these p&p charges should be doubled. For orders over £100.00 in value, p&p charges will be advised.

SUBSCRIPTIONS & PAST ISSUES

Subscriptions and past issues, if available, should be ordered from **Worldwide Subscription Service Ltd, Unit 4, Gibbs Reed Farm, Pashley Road, TICEHURST TN5 7HE, England**. For subscriptions, use the order form on the opposite page. Prices of past issues (except July/August and December), including postage for single copies, are £2.70 (UK and Eire); £3.00 (surface mail outside UK); £3.20 (air mail Europe); £3.95 (airmail outside Europe). Prices of past July/August and December issues, including postage for single copies, are £3.75 (UK); £4.00 (surface mail outside UK); £4.25 (airmail Europe); and £5.00 (airmail outside Europe).

PAST ARTICLES

Photocopies of articles from January 1978 onwards can be provided, postage paid, at £1.95 (UK and Eire), £2.10 (surface mail outside UK), £2.45 (airmail Europe), or £2.70 (airmail outside Europe). In case an article is split into instalments, these prices are applicable **per instalment**. Photocopies may be ordered from our editorial and administrative offices.

COMPONENTS

Components for projects appearing in *Elektor Electronics* are usually available from appropriate advertisers in this magazine. If difficulties in the supply of components are envisaged, a source will normally be advised in the article. It should be noted that the source(s) given is (are) not exclusive — other suppliers may also be able to help.

BOOKS

For book availability, see advertisement on page 67.

SHELF BOX

Elektor Electronics shelf box£2.95.....\$6.00

FRONT PANEL FOILS

PROJECT	No.	Price (£)	Price (US\$)
Timecode interface	910055-F	8.80	17.60
Digital function generator	910077-F	10.60	21.20
4-Megabyte printer buffer	910110-F	11.45	22.90
FM tuner	920005-F	13.20	26.40
4MB printer buffer card	920009-F	8.25	16.50
LC meter	920012-F	11.45	22.90
Guitar tuner	920033-F	8.80	17.60
NICAM decoder	920035-F	8.25	16.50
12VDC to 240VAC inverter	920038-F	16.15	32.30
Audio DAC	920063-F	10.00	20.00
Dig. audio/visual system	920022-F1	10.00	20.00
	920022-F2	19.40	38.80
	920022-F3	28.80	57.60
1.2 GHz multifunction frequency meter	920095-F	13.80	27.60
U2400B NiCd battery charger	920098-F	8.75	17.50
Workbench PSU	930033-F	17.00	34.00

PROJECT	No.	Price (£)	Price (US\$)
Inexpensive phase meter	930046-F	17.25	34.50
Mini preamplifier	930106-F	Not available	
AF rms voltmeter	930108-F	17.25	34.50

EPROMS / PALS / MICROCONTROLLERS

Amiga mouse/joystick switch (1 x GAL 16V8)	6001	8.25	16.50
4-Megabyte printer buffer (1 x 2764)	6041	15.30	30.60
8751 emulator incl. system disk (MSDOS)	6051	29.40	58.80
Connect 4 (1 x 27C64)	6081	15.30	30.60
EMON51 (8051 assembler course) (1 x 27256+disk 1661)	6061	20.00	40.00
EMON51 (8051 assembler course) (1 x 27256+disk 1681)	6091	20.00	40.00
FM tuner (1 x 27C256)	6101	15.30	30.60
Multi-purpose Z80 card: GAL set (2 x GAL 16V8)	6111	11.15	22.30
Multi-purpose Z80 card: BIOS (1 x EPROM 27128)	6121	15.30	30.60
1.2 GHz multifunction frequency meter (1 x 27C256)	6141	11.45	22.90
Digital audio/visual system (1 x 27C256)	6171	10.30	20.60
TV test pattern generator (1 x 27256)	6151	13.00	26.00
DiAV system. Package: 1 x 27512; 2 x GAL; 1 x floppy disk (MSDOS)	6181	30.50	61.00
PAL test pattern generator (1 x GAL 20V8-25)	6211	9.40	18.60
80C535 assembler course (1 x EMON52 EPROM and 1 x disk 1811)	6221	17.05	34.10
Watt-hour meter (1 x 27256)	6241	10.00	20.00
Four fold DAC (1 x GAL)	6251	10.75	21.50
Multipurpose display decoder (1 x 2764)	6261	11.50	23.00
Telephone-controlled switch (1 x 2764)	6271	14.50	29.00
Relative humidity meter (1 x 2764)	6301	14.50	29.00
535 card w. EPROM emulator (1 x PAL; 1 x GAL)	6311	26.00	52.00
Copybit eliminator (1 x GAL 16V8 and 1 x MACH110)	6321	42.25	84.50
RDS decoder (1 x 27C64)	6331	14.50	29.00
I ² C tester (1 x GAL 6001)	6341	30.75	61.50
Mains signalling system (1 x 27C64)	6371	13.25	26.50
8751 programmer (1 x 8751)	7061	46.40	92.80
Microcontroller NiCd charger (1 x ST62E15)	7071	10.00	20.00
Maxi micro clock (clock)	7081	11.50	23.00
Maxi micro clock (darkroom timer)	7091	11.50	23.00
Maxi micro clock (cooking timer)	7101	11.50	23.00
Mini micro clock (clock)	7111	11.50	23.00
Mini micro clock (darkroom timer)	7121	11.50	23.00
Mini micro clock (cooking timer)	7131	11.50	23.00
VHF/UHF TV tuner (1 x 87C51)	7141	25.75	51.50
Microntroller-driven UART (1 x ST62T10)	7151	17.25	34.50
PIC programmer (1 x PIC17C42 and 1 x disk)	7161	50.00	100.00

DISKETTES

Plotter driver (D. Sijtsma)	1541	11.15	22.30
I/O interface for Atari	1571	7.65	15.30
Tek/Intel file converter	1581	7.65	15.30
B/W video digitizer	1591	11.15	22.30
Timecode interface	1611	7.65	15.30
RTC for Atari ST	1621	7.65	15.30
24-bit colour extension for video digitizer	1631	11.15	22.30
PC controlled weather station - 3 (superseeds disks 1551 and 1561)	1641	7.65	15.30
8051/8032 Assembler course (IBM version)	1661	7.65	15.30
8051/8032 Assembler course (Atari version) (3.5")	1681	7.65	15.30
AD232 converter	1691	7.65	15.30
GAL programmer (3 disks;			

PROJECT	No.	Price (£)	Price (US\$)
upgrade: June 1993)	1701	11.15	22.30
Multi-purpose Z80 card	1711	7.65	15.30
Fuzzy Control One	1721	7.75	15.50
Pascal library for MMC	1751	9.70	19.40
Speech/sound memory	1771	7.65	15.30
PC-aided transistor tester	1781	7.50	15.00
IR receiver and DTMF decoder for 80C32 SBC	1791	9.00	18.00
80C535 assembler course	1811	8.80	17.60
I ² C opto/relay card	1821	7.65	15.30
Video digitizer for PCs	1831	14.50	29.00
GAL programmer for Amiga	1841	11.00	22.00
I ² C alphanumeric display	1851	8.50	17.00
Philips preamplifier	1861	8.50	17.00
GAL programmer (excl. Opal Jr. disks)	1881	10.75	21.50
Precision clock for PCs	1871	8.50	17.00
X2404-to-8751 interfacing	1891	8.50	17.00
Mains signalling system	1911	9.75	19.50
SIM — an 8051 simulator	1931	34.25	68.50

PRINTED CIRCUIT BOARDS

Printed circuit boards whose number is followed by a + sign are only available in combination with the associated software item, and can **not** be supplied separately. The indicated price includes the software.

JANUARY 1994

Digital dial	920161	12.75	25.50
RDS decoder incl. EPROM (6331)	930121+	23.75	51.50
I ² C tester incl. GAL (6341)	930128+	36.25	72.50
Telephone-controlled switch incl. EPROM (6271)	934054+	37.25	74.50

FEBRUARY 1994

80C535 single-board computer	924046	14.10	28.20
Copybit eliminator incl. MACH and GAL	930098+	46.25	92.50
Mini preamplifier	930106	29.25	58.50
Bidirectional RS232-to-Centronics converter	930134	14.00	28.00
24 cm FM ATV transmitter	PCB available from author		

MARCH 1994

PIC programmer incl. software set 7161	940048+	64.75	129.50
100W AF amplifier - adaptor board	930039	8.25	16.50
- amplifier board	920135-1	19.40	38.80
- protection board	920135-2	7.95	15.90
Mini I/O card for Casio FX850/880P	930090	Not available	
AF signal tracer	940006	Not available	
Electronic fuse	936071	Not available	

APRIL 1994

Mains signalling system - 1 (receiver)	940021-1	10.25	20.50
68HC11 processor board	930123	7.75	15.50
RS232 speedometer	930119	Not available	
Stroboscope light	940022	Not available	
Headphones amplifier	940016	18.75	37.50
Halogen light dimmer	940034	Not available	
RS232 interface for universal bus	924048	Not available	

MAY 1994

Differential probe for oscilloscopes	940018	7.75	15.50
Mains signalling system - 2 (transmitter) (incl. disk 1911 and EPROM 6371)	940021-2+	33.25	66.50
Morse decoder contact Velleman distributor			
General-purpose sensor monitor	916107	Not available	
TV sound to light unit	936038	Not available	

TERMS OF BUSINESS

HOW TO PAY

Unless you have an approved credit account with us, all orders must be accompanied by the full payment, including postage and packing charges as stated on page 70, section 1.

Payment may be made by cheque **drawn on a London clearing bank** (but see para. 4 below), postal order, VISA, ACCESS, MASTERCARD or EUROCARD (when paying by credit card, the order must go to the cardholder's address). Do not send cash through the mail. Cheques and postal orders should be crossed and made payable to 'Elektor Electronics (Publishing)'.

Payment may also be made by direct transfer from a private or business Giro account to our **Giro Account No. 34 152 3801** by completing and sending to the National Giro Centre, in a National Giro postage paid envelope, a National Giro transfer/deposit form. Do not send Giro transfers direct to us, as this will delay your order.

If you live outside the UK, payment may also be made by Bankers' sterling draft drawn on a London clearing bank, Eurocheque **made out in pounds sterling** (with holder's guarantee card number written on the back), or US or Canadian dollar cheque, but such cheques, accepted at the exchange rate prevailing at the time your order is received, **must be increased by the equivalent of £15.00** to cover our bankers' negotiating fee.

If you pay by Bankers' sterling draft, make clear to the issuing bank that your full name and address **MUST** be communicated to the London clearing bank.

Our bankers are **National Westminster Bank PLC, 100 High Street, BRENTFORD**

TW8 8AY, England. Our account number is **4285 0134**.

DELIVERY

Although every effort will be made to dispatch your order within 2-3 weeks from receipt of your instructions, we can not guarantee this time scale for all orders.

RETURNS

Faulty goods or goods sent in error may be returned for replacement or correction, but not before obtaining our consent. All goods returned should be packed securely in a padded bag or box, enclosing a covering letter stating the dispatch note number. If the goods are returned because of a mistake on our part, we will refund the return postage. Goods returned for refund must be in resalable condition and will be subject to a 10% handling charge with a minimum charge of £2.50.

DAMAGED GOODS

Claims for damaged goods must be received at our Dorchester office within 10 days (UK); 14 days (Europe) or 21 days (all other countries) from the date on our "Recorded Delivery" slip.

CANCELLED ORDERS

All cancelled orders will be subject to a 10% handling charge with a minimum charge of £2.50.

PATENTS

Patent protection may exist in respect of circuits, devices, components, and so on, described in our books or magazines. Elektor Electronics (Publishing) do not accept responsibility or li-

ability for failing to identify such patent or other protection.

COPYRIGHT

All drawings, photographs, articles, printed-circuit boards, EPROMs, and cassettes published in our books or magazines (other than in third-party advertisements) are copyright and may not be reproduced or transmitted in any form or by any means, including photocopying and recording, in whole or in part, without the prior permission of Elektor Electronics (Publishing) in writing. Such written permission must also be obtained before any part of these publications is stored in a retrieval system of any nature.

Notwithstanding the above, printed-circuit boards may be produced for private and personal use without prior permission.

LIMITATION OF LIABILITY

Elektor Electronics (Publishing) shall not be liable in contract, tort, or otherwise, for any loss or damage suffered by the purchaser whatsoever or howsoever arising out of, or in connexion with, the supply of goods or services by Elektor Electronics (Publishing) other than to supply goods as described or, at the option of Elektor Electronics (Publishing), to refund the purchaser any money paid in respect of the goods.

LAW

Any question relating to the supply of goods and services by Elektor Electronics (Publishing) shall be determined in all respects by the laws of England.

May 1994

Annual subscription rates (1994)

United Kingdom	£ 27.00
Rest of the world (surface mail)	£ 33.00
A I R M A I L	
Europe & Eire	£ 34.00
USA & Canada	\$57.00
Middle East & North Africa	£ 43.00
Central & southern Africa	£ 43.00
Central & South America	£ 43.00
Australia & New Zealand	£ 45.00
Far East & South Pacific regions	£ 45.00

Payment may be made by cheque in sterling **drawn on a London clearing bank** (but see below), postal order, VISA, ACCESS, MASTERCARD or EUROCARD (in which case the subscription must be sent to the cardholder's address) or by direct transfer to our Giro Account no. 34 152 3801. Do not send cash through the mail. Cheques and postal orders should be made payable to 'Elektor Electronics Publishing'. Giro transfers should be made by completing and sending the appropriate transfer/deposit form to the National Giro Centre (UK) or to your national Giro Centre.

If you live outside the United Kingdom, payment may also be made by Bankers' sterling draft drawn on a London clearing bank or Eurocheque. Eurocheques should be made out in pounds sterling and have the holder's guarantee card number written on the back.

US dollar cheques. Subscribers in the USA and Canada

only may pay in \$US cheques.

The **standard subscription order period** is twelve months. If a permanent change of address during your subscription period means that copies have to be dispatched by a more expensive service, no extra charge will be made. Similarly, no refund will be made, nor expiry date extended, if a change of address allows the use of a cheaper service.

Student applications, which qualify for a 10% (ten per cent) reduction in current rates, must be supported by evidence of studentship signed by the head of the college, school or university faculty.

Please note that **new subscriptions** take about four weeks from receipt of order to become effective.

Cancelled subscriptions will be subject to a charge of 25% (twenty-five per cent) of the full subscription price or £7.50, whichever is the higher, plus the cost of any issues already dispatched. Subscriptions cannot be cancelled after they have run for six months or more.

Our bankers are National Westminster Bank PLC, Sorting Code 60-03-23, 100 High Street, Brentford TW8 8AY, England. Our account number is 4285 0134.

May 1994

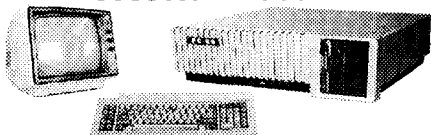
Surplus always
wanted for cash!

THE ORIGINAL SURPLUS WONDERLAND!

Surplus always
wanted for cash!

LOW COST PC SPECIALISTS - ALL EXPANDABLE - ALL PC COMPATIBLE

8088 XT - PC99



- 256k RAM - expandable to 640k
- 4.7 Mhz speed
- 360k 5-1/4" floppy
- 2 serial & 1 parallel ports
- MS-DOS 4.01
- Factory burnt-in
- Standard 84 key keyboard
- 12" green screen included
- In good used condition

Optional FITTED extras: 640K RAM £39. 12" CGA colour monitor with card £39. 2nd 5-1/4" 360k floppy £29.95. 20 mbyte MFM hard drive £99.

Only **£99.00** (F)

FLOPPY DISK DRIVES

5 1/4" from £22.95 - 3 1/2" from £21.95!

Massive purchases of standard 5 1/4" and 3 1/2" drives enables us to present prime product at industry beating low prices! All units (unless stated) are removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. All are IBM-PC compatible (if 3 1/2" supported).

- 3.5" Panasonic JU363/4 720K or equivalent £29.95(B)
- 3.5" Mitsubishi MF355C-L 1.4 Meg. Laptops only £29.95(B)
- 3.5" Mitsubishi MF355C-D 1.4 Meg. Non laptop £29.95(B)
- 5.25" EXTRA SPECIAL BRAND NEW Mitsubishi MF501B 360K. Absolutely standard fits most computers £22.95(B)

* Data cable included in price.

- Shugart 800/801 SS refurbished & tested £175.00(E)
- Shugart 851 double sided refurbished & tested £275.00(E)
- Mitsubishi M2894-63 double sided switchable hard or soft sectors- BRAND NEW £250.00(E)

Dual 8" drives with 2 mbyte capacity housed in a smart case with built in power supply! Ideal as exterior drives! £499.00(F)

End of line purchase scoop! Brand new NEC D2246 8" 85 megabyte of hard disk storage! Full CPU control and industry standard SMD interface. Ultra hi speed transfer and access time leaves the good old ST506 interface standing. In mint condition and comes complete with manual. Only £299(E)

THE AMAZING TELEBOX!

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND
& VIDEO
TUNER!

The TELEBOX consists of an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by manufacturers such as MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD and many more. The composite video output will also plug directly into most video recorders, allowing reception of TV channels not normally receivable on most television receivers (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television or video channels. TELEBOX MB covers virtually all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators. Composite and RGB video outputs are located on the rear panel for direct connection to most makes of monitor. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

- Telebox ST for composite video input monitors £32.95
- Telebox STL as ST but with integral speaker £36.50
- Telebox MB as ST with Multiband tuner VHF-UHF-Cable. & hyperband For overseas PAL versions state 5.5 or 6mhz sound specification. £69.95
- Telebox RGB for analogue RGB monitors (15khz) £69.95

Shipping code on all Teleboxes is (B)

RGB Telebox also suitable for IBM multisync monitors with RGB analog and composite sync. Overseas versions VHF & UHF call. SECAM/ NTSC not available.

No Break Uninterruptable PSU's

Brand new and boxed 230 volts uninterruptable power supplies from **Densei**. Model MUK 0565-AUAF is 0.5 kva and MUD 1085-AHBH is 1 kva. Both have sealed lead acid batteries. MUK are internal, MUD has them in a matching case. Times from interrupt are 5 and 15 minutes respectively. Complete with full operation manuals.....MUK.....£249 (F) MUD.....£525 (G)

286 AT - PC286



- 640k RAM expandable with standard SIMMS
- 12 Mhz Landmark speed
- 20 meg hard disk
- 1.2 meg 5-1/4" floppy
- 1.4 meg 3-1/2" floppy
- EGA driver on board
- 2 serial & 1 parallel ports
- MS-DOS 4.01
- Co-processor socket
- Enhanced 102 key keyboard
- Clock & calendar with battery back up

BRAND NEW AND BOXED!

Only **£249.00** (F)

The Philips 9CM073 is suggested for the PC286 and the CM8873 for the PC386. Either may use the SVGA MTS-9600 if a suitable card is installed. We can fit this at a cost of £49.00 for the PC286 and £39.00 for the PC386.

POWER SUPPLIES

Power One SPL200-5200P 200 watt (250 w peak). Semi open frame giving +5v 35A, -5v 1.5A, +12v 4A (8A peak), -12v 1.5A, +24v 4A (6A peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims 13" x 5" x 2.5". Fully guaranteed RFE. £85.00 (B)

Power One SPL130. 130 watts. Selectable for 12v (4A) or 24 v (2A). 5v @ 20A, +12v @ 1.5A. Switch mode. New. £59.95(B)

Astec AC-8151 40 watts. Switch mode. +5v @ 2.5A, +12v @ 2A, -12v @ 0.1A, 6-1/4" x 4" x 1-3/4" New. £22.95(B)

Greendale 19AB0E 60 watts switch mode. +5v @ 6A, +12v @ 1A, +15v @ 1A. RFE and fully tested. 11 x 20 x 5.5cms. £24.95(C)

Conver AC130. 130 watt hi-grade VDE spec. Switch mode. +5v @ 15A, -5v @ 1A, +12v @ 6A, 27 x 12.5 x 6.5cms. New. £49.95(C)

Boshert 13090. Switch mode. Ideal for drives & system. +5v @ 6A, +12v @ 2.5A, -12v @ 0.5A, -5v @ 0.5A. £29.95(B)

Farnell G6/40A. Switch mode. 5v @ 40A. Encased. £95.00(C)

Farnell G24/5S. As above but 24v @ 5A. £65.00(C)

BBC Model B APM Board

WIN £100
CASH!

£100 CASH FOR THE
MOST NOVEL
DEMONSTRATABLE
APPLICATION!

BBC Model B type computer on a board. A major purchase allows us to offer you the PROFESSIONAL version of the BBC computer at a parts only price. Used as a front end graphics system on large networked systems the architecture of the BBC board has so many similarities to the regular BBC model B that we are sure that with a bit of experimentation and ingenuity many useful applications will be found for this board!! It is supplied complete with a connector panel which brings all the I/O to 'D' and BNC type connectors - all you have to do is provide +5 and +12 v DC. The APM consists of a single PCB with most major ic's socketed. The ic's are too numerous to list but include a 6502, RAM and an SAA5050 teletext chip. Three 27128 EPROMs contain the custom operating system on which we have no data. On application of DC power the system boots and provides diagnostic information on the video output. On board DIP switches and jumpers select the ECONET address and enable the four extra EPROM sockets for user software. Appx. dims: main board 13" x 10". I/O board 14" x 3". Supplied tested with circuit diagram, data and competition entry form.

Only **£29.95 or 2 for £53** (B)

SPECIAL INTEREST

- Trio 0-18 vdc bench PSU. 30 amps. New £ 470
- Fujitsu M3041 600 LPM band printer £2950
- DEC LS/02 CPU board £ 150
- Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBT F2 Modulator £6500
- Calcomp 1036 large drum 3 pen plotter £ 650
- Thurby LA 160B logic analyser £ 375
- 1.5kw 115v 60hz power source £ 950
- Anton Pillar 400 Hz 3 phase frequency converter 75Kw POA
- Newton Derby 400 Hz 70 Kw converter POA
- Nikon PL-2 Projection lens meter/scope £750
- Sekonic SD 150H 18 channel Hybrid recorder £2000
- HP 7580A A1 8 pen high speed drum plotter £1850
- Kenwood DA-3501 CD tester, laser pickup simulator £ 350

BRAND NEW PRINTERS

- Microline 183. NLQ 17x17 dot matrix. Full width. £139 (D)
- Hyundai HDP-920. NLQ 24x18 dot matrix full width. £149 (D)
- Qume LetterPro 20 daisy. Qume QS-3 interface. £39.95 (D)
- Centronics 152-2 9 x 7 dot matrix. Full width. £149 (D)
- Centronics 159-4 9 x 7 dot matrix. Serial. 9-1/2" width £ 99 (D)

386 AT - PC386

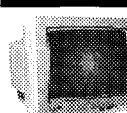


- 2 meg RAM expanded by slots
- 20 Mhz with 32k cache. Expandable to 64k
- 40 meg hard disk
- 1.2 meg 5-1/4" floppy
- VGA card installed
- 2 serial & 1 parallel ports
- MS-DOS 4.01
- Co-processor socket
- Enhanced 102 keyboard
- Kwik Disk Accelerator Software - FREE

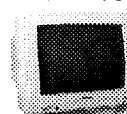
BRAND NEW AND BOXED!

Only **£425.00** (F)

MONITORS



14" Forefront Model MTS-9600 SVGA multisync with resolution of 1024 x 768. 0.28 pitch. "Text" switch for word processing etc. Overscan switch included. Ideal for the PC-386 or PC-286 with SVGA card added. Also compatible with BBC, Amiga, Atari (including the monochrome high resolution mode), Archimedes etc. In good used condition (possible minor screen burns). 90 day guarantee. 15" x 14" x 12". Only £159(E)



14" Philips Model CM8873 VGA multisync with 640 x 480 resolution. CGA, EGA or VGA, digital/analog, switch selectable. Sound with volume control. There is also a special "Text" switch for word processing, spreadsheets and the like. Compatible with IBM PC's, Amiga, Atari (excluding the monochrome high resolution mode), BBC, Archimedes etc. Good used condition (possible minor screen burns) 90 day guarantee. 15" x 14" x 12". Only £139(E)

Philips 9CM073 similar (not identical) to above for EGA/CGA PC and compats. 640 x 350 resolution. With Text switch with amber or green screen selection. 14" x 12" x 13-1/2" £99(E)

KME 10" high definition colour monitors. Nice tight 0.28" dot pitch for superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13.5" x 12" x 11". Also works as quality TV with our HUB Telebox. Good used condition. 90 day guarantee. Only £125(E)

KME as above for PC EGA standard. £145(E)

Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubishi 0.42 dot pitch giving 669 x 507 pixels. Big 28 Mhz bandwidth. A super monitor in attractive style moulded case. Full 90 day guarantee. Only £129(E)

NEC CGA 12" IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15"L x 13"W x 12"H. The front cosmetic bezel has been removed for contractual £69 (E)

20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & sound inputs. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs. In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

CALL FOR PRICING ON NTSC VERSIONS!

Superb Quality 6 foot 40u

19" Rack Cabinets

Massive Reductions

Virtually New, Ultra Smart!

Less Than Half Price!

Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels or stand singly. Overall dimensions are 77-1/2"H x 32-1/2"D x 22"W. Order as:

Rack 1 Complete with removable side panels.....£275.00 (G)

Rack 2 Less side panels.....£145.00 (G)

DISPLAY

MAIL ORDER & OFFICES
Open Mon-Fri 9.00-5.30
Dept EL. 32 Biggin Way,
Upper Norwood,
London SE19 3XF.

LONDON SHOP
Open Mon-Sat 9.5-3.30
Thursday till 9.00pm
215 Whitehorse Lane,
South Norwood,
London, SE25.

DISTEL © The Original
Free dial-up database!
1000's of items+info on line
V21, V22 & V22 bis
081-679-1888

ALL ENQUIRIES
081-679-4414
Fax: 081-679-1927



-ELECTRONICS-

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. PO orders from Government, Universities, Schools & Local Authorities welcome-minimum account order £30. Carriage charges (A)=£2.00, (A1)=£3.75, (B)=£5.50, (C)=£8.50, (D)=£11.50, (E)=£14.00, (F)=£18.00 (G)=Call. Scotland surcharge: call. All goods supplied subject to our standard Conditions of Sale and unless otherwise stated guaranteed for 90 days. All quantities on a return to base basis. Rights reserved to change prices & specifications without prior notice. Orders subject to stock. Quotations willingly given for higher quantities than those stated. Bulk surplus always wanted for cash.

ELEKTOR ELECTRONICS is available from, among others:

**CRICKLEWOOD
ELECTRONICS LIMITED**
40 Cricklewood Broadway,
London NW2 3ET
Telephone 081 450 0995
Fax 081 208 1441

THE ELECTRONIC SHOP
Electronic components, test
equipment, telephone
accessories, computer
accessories, microphones,
disco lighting, speakers, turn
tables, mixers, meters, stylus.
29 Hanging Ditch,
Manchester M4 3ES.
Telephone 061 834 1185

GREENWELD
27 Park Road
Southampton SO1 3TB
England
Telephone (0703) 236 363
Fax (0703) 236 307

L.F. HANNEY
Your electronic component
specialist for Avon, Wilts &
Somerset.
77 Lower Bristol Road, Bath,
Avon, Telephone 0225
424811

**D.P. HOBBS (NORWICH)
LTD**
Electronic component
specialists. Amateur radio
equipment.
13 St. Benedict Street,
Norwich NR2 4PE,
Telephone 0603 615786

MANCOMP
240 Platt Lane
Manchester M14 7BS
England
Telephone 061 224 1888

OMNI ELECTRONICS
Stock a wide range of
electronic components.
174 Dalkeith Road,
Edinburgh EH16 5DX,
Telephone 031 667 2611

AAGE NIELSEN
1 Sortedam Dosseringen
DK-2200 Copenhagen,
Denmark,
Telephone 01 39 30 10
Fax 031 39 05 02

HELMHOLT ELEKTRONIK
Farvevej 2
DK-7600 Struer, Denmark
Telephone 97 85 26 11

**RCE ELECTRONIC
CENTRE**
Boulevard 34
DK-9000 Aalborg, Denmark
Telephone 98 16 07 10

VEJLE RC ELEKTRONIK
Sdr Brogade 42
P O Box 332
DK-7100 Vejle, Denmark
Telephone 75 83 25 33

BEBEK ELECTRONICS
Hirsimetsäntie 26
SF-15200 Lahti 11
Finland
Telephone (18) 33 99 46

TABACCARIA BRITANICA
Praça do Duque da
Terceira 19
1107 Lisboa, Portugal
Telephone 932 4752

MK KNJIGARNA
Slovenska 29
Ljubljana
Slovenia
Telephone 061 150 196

**TECHNICAL BOOKS &
MAGAZINES**
289-299 Swanston Street
Melbourne, Australia 3000
Telephone 663 3951

INEL Co.
P.O. Box 1397
JL. Hariang Banga No. 3
Bandung 40116
Indonesia

INDEX OF ADVERTISERS

Advertising Standards Authority	36, 51	Those Engineers	59
Badger Boards	49	Tsien (UK) Ltd	55
B K Electronics	15	Ultimate Technology	Inside front cover
Bull Electrical	60	Viewcom Electronics	8, 9
Canal Bridge Audio	51		
Circuit Distribution	27		
Cricklewood Electronics	45		
Display Electronics	73		
Elektor Electronics	67, 74		
ESR Electronic Components	31		
Eurocom International Ltd	51		
Hitex (UK) Ltd	36		
Instrutek (UK)	21		
Intar Oy	51		
KMN Developments	49		
Labcenter	61		
Maplin Electronic Supplies	Back cover		
MicroAmps	27		
Number One Systems Ltd	4		
Pico Technology Ltd	26		
POWERware	59		
Robinson Marshall	Inside back cover		
SigCad	49		
Speaker Builder	36		
Stewart of Reading	27		
Suma Designs	20		

ADVERTISING SPACE

for the June 1994 issue may be reserved
not later than Thursday 14 April 1994 by

Elektor Electronics (Publishing)
Advertisement Office
3 Crescent Terrace
Cheltenham GL50 3PE
England
Telephone (0242) 510 760
Fax (0242) 226 626

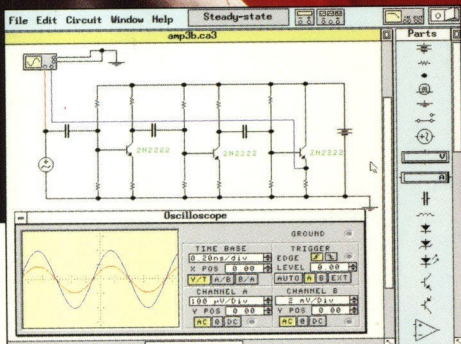
to whom all correspondence, copy instructions
and artwork should be addressed.

Design and Verify Circuits. Fast.

DOS, Windows
versions available

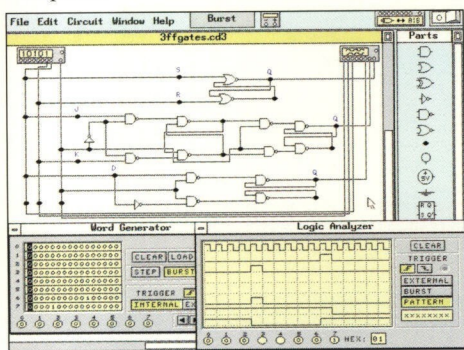
Electronics Workbench®

NEW Version 3



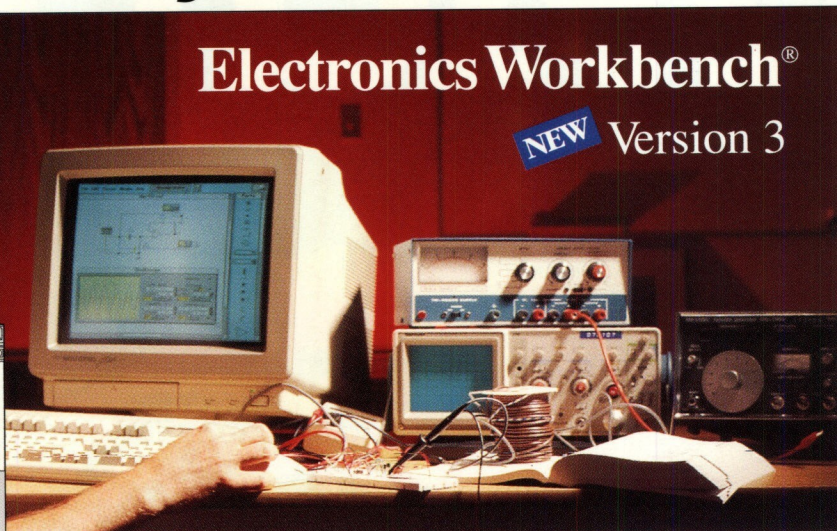
Analog Module includes:

- complete control over all component values
- ideal and real-world models for active components
- resistors, capacitors, inductors, transformers, relays, diodes, Zener diodes, LEDs, BJTs, opamps, bulbs, fuses, JFETs, and MOSFETs
- manual, time-delay, voltage-controlled and current-controlled switches
- independent, voltage-controlled and current-controlled sources
- multimeter
- function generator (1 Hz to 1 GHz)
- dual-trace oscilloscope (1 Hz to 1 GHz)
- Bode plotter (1 mHz to 10 GHz)
- SPICE simulation of transient and steady-state response



Digital Module includes:

- fast simulation of ideal components
- AND, OR, XOR, NOT, NAND and NOR gates
- RS, JK and D flip-flops
- LED probes, half-adders, switches and seven-segment displays
- word generator (16 eight-bit words)
- logic analyzer (eight-channel)
- logic converter (converts among gates, truth table and Boolean representations)



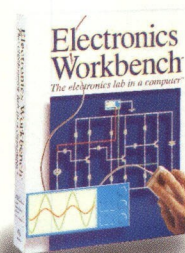
Complement Your Test Bench

Here's why Electronics Workbench belongs on *your* test bench: Wires route themselves. Connections are always perfect. And the simulated components and test instruments work just like the real thing. The instruments are indestructible and the parts bin holds an unlimited supply of each component. The result: thousands of electronics professionals and hobbyists save precious time and money. **Over 90% would recommend it to their friends and colleagues.** Electronics Workbench: the ideal, affordable tool to design and verify your analog and digital circuits before you breadboard.

And now the best is even better - Electronics Workbench Version 3.0 is here. It simulates more and bigger circuits, and sets the standard for ease of use. Guaranteed!

NEW Features in Version 3

- new components include JFETs, MOSFETs, voltage-controlled and current-controlled sources and manual, time-delay, voltage-controlled and current-controlled switches
- real-world models for opamps, BJTs, JFETs, MOSFETs and diodes - over 100 models available
- MS-DOS version now supports up to 16 MB of RAM for simulation of bigger circuits
- new Microsoft® Windows™ version available
- technical support now also available on CompuServe®



Just £199!

Electronics Workbench®

The electronics lab in a computer™

Call: (0827) 66212



ROBINSON MARSHALL (EUROPE) LTD.

17 Middle Entry, Tamworth, Staffordshire, England B79 7NJ
Fax: (0827) 58533

*30-day money-back guarantee.

Shipping charges - UK £4.99. All prices are plus V.A.T.
All trademarks are the property of their respective owners.



NEW

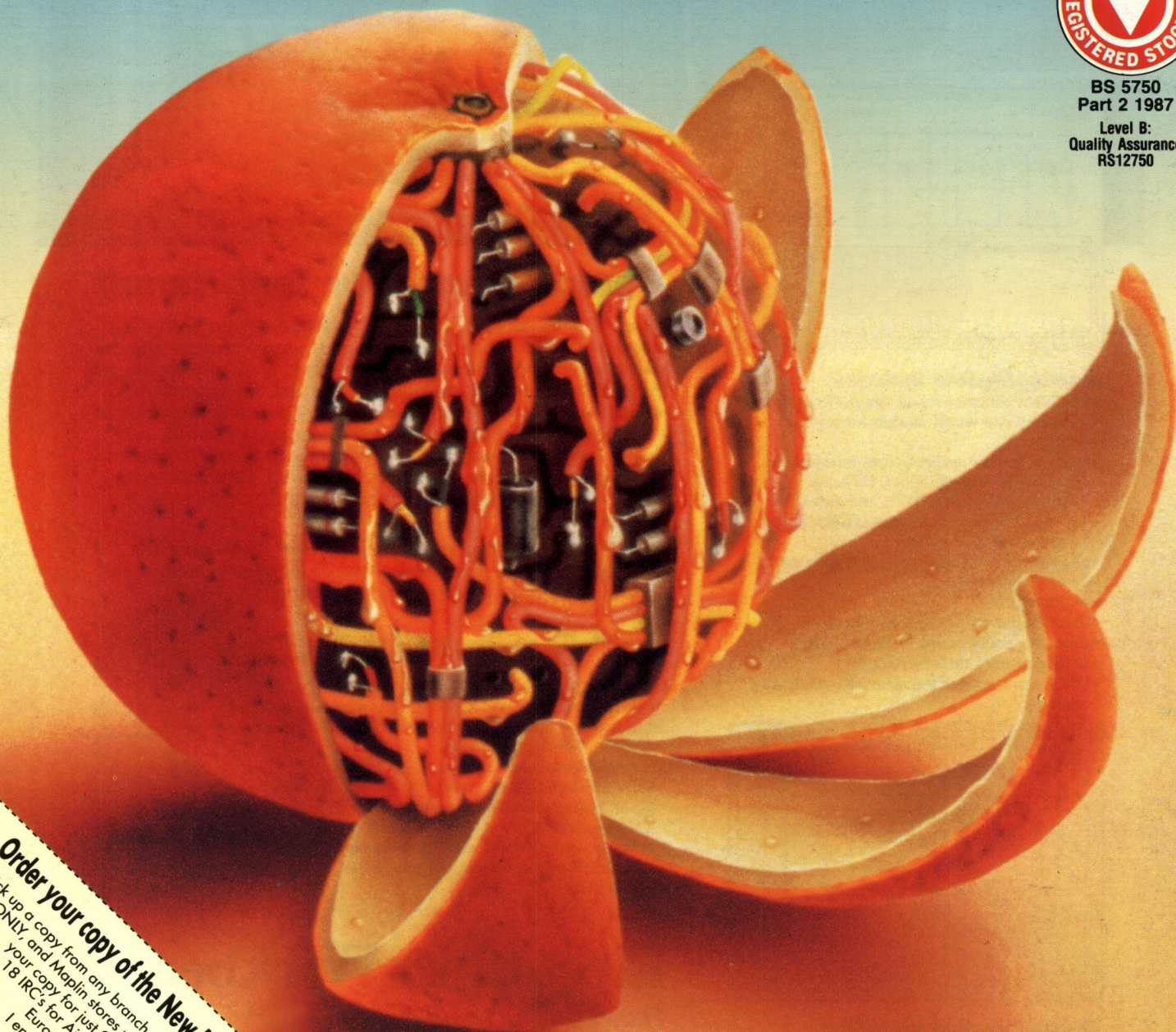
FULL COLOUR GUIDE TO ELECTRONIC PRODUCTS

Maplin



BS 5750
Part 2 1987

Level B:
Quality Assurance
RS12750



Order your copy of the New MAPLIN Catalogue on sale NOW!
Pick up a copy from any branch of WHSMITH, selected branches of RSM^{COLL} in Scotland ONLY, and Maplin stores nationwide for just £2.95 or post this coupon now to receive your copy for just £3.45 inc. p&p. If you live outside the U.K. send £6.80 or 18 IRC's for Airmail in Europe/£5.20 or 13 IRC's for surface mail outside Europe; or £11.50 or 30 IRC's for Airmail outside Europe.
I enclose £3.45/£6.80/£5.20/£11.50 (delete as applicable).

Name.....
Address.....

Post Code.....
Send to Maplin Electronics,
P.O. Box 3, Rayleigh,
Essex, England
SS6 8LR.
ELK94

Over 700 colour packed pages with hundreds of brand New Products at Super Low Prices, on sale now, **only £2.95.**

Available from all branches of WHSMITH, selected branches of RSM^{COLL} in Scotland ONLY, and Maplin stores nationwide.
The Maplin Electronics 1994 Catalogue – **UNIQUELY DIFFERENT!**
Africa customers please contact MAPLIN (SOUTHAFRICA) Tel: (024) 51-5124